TITLE OF THE INVENTION

WORK ASSIGNMENT SYSTEM AND METHOD, DISTRIBUTED CLIENT/SERVER SYSTEM, AND COMPUTER PROGRAM STORAGE MEDIUM

FIELD OF THE INVENTION

The present invention relates to a work assignment method and system for composing a plurality of work standards in, e.g., an assembly work, a distributed client/server system, and a computer program storage medium.

BACKGROUND OF THE INVENTION

Conventionally, in a field of designing/manufacturing a production line for mass production, in building a desired production line at an actual site of production or improving an existing production line, an operation of individually assigning necessary works to a plurality of processes of the production line is done before actually manufacturing or improving the production line.

To assembly a product from parts, an enormous number of parts are required. The larger the number of parts becomes, the more enormous and complex the works become.

Conventionally, an experienced chief of the workshop, who knows the enormous number of complex works well, manually arranges the works, calculates the manhour, and assigns operators in units of manhours.

However, it is hard even for the experienced workshop chief who knows various works well to examine exchange of an enormous number of works in consideration of the capability of each operator and the work capability of each station that is actually determined depending on the difficulty of a work, and to manually adjust the load balance of each station to a balanced state on the basis of the examination result.

In addition, this manual composing operation accompanies poor maintenance because it is not only time-consuming but also difficult to correct and can be understood only by the creator.

SUMMARY OF THE INVENTION

The present invention has been made to solve the above problem, and has as its object to propose a work assignment system for automatically and efficiently assigning a work formed from a plurality of work standards to a plurality of stations by a computer to compose the work.

In order to achieve the above object, a work assignment system according to the present invention is characterized by the following arrangement.

More specifically, there is provided a work assignment system for assigning and composing a work formed from a plurality of work standards to a plurality of stations, characterized by comprising:

display means (37706) for displaying names of the plurality of work standards as composition targets;

condition input means (37710) for inputting a composition condition;

assignment means (37720e) for dividing the plurality of work standards in accordance with the composition condition and assigning one group of the divided work standards to a station; and

output means (9001-9004) for outputting an assignment result of the work standards of each station to a work assignment file as a composition plan.

According to a preferred aspect of the present invention, the output means displays, on the display means, the names of the work standards assigned to each station in units of stations. The division result is easy to confirm.

For simple division, the composition condition is preferably an average value of manhours necessary to execute all the work standards in the station.

According to another preferred aspect of the present invention, each of the plurality of work standards as the composition targets has manhour value data, and

the system further comprises

calculation means for calculating a total manhour of the plurality of work standards, and

means for entering a value of the total manhour calculated by the calculation means as partial data of the

composition condition.

With this arrangement, composition condition data input can be partially automated.

For composition condition data that cannot be automatically input, the condition input means displays, on the display means, a user interface for inputting the number of units to be produced in one day, an operation time of a production workshop, and a target composition efficiency as the composition conditions.

According to still another preferred aspect of the present invention, the system further comprises

means for displaying an arbitrary work standard group, and

user interface means for selecting the plurality of work standards as the composition targets from the displayed work standard group.

According to still another preferred aspect of the present invention, the arbitrary work standard group is classified into one of a component group formed from a plurality of work standards, a model group formed from a plurality of components, a representative model group formed from a plurality of models, and a genre group formed from a plurality of representative models. The user can efficiently select a work standard whose degree of complexity corresponds to the assembly phase of the applied site.

Some works can be parallelly processed. In this case,

a plurality of composition plans can be provided. More specifically, the system according to still another preferred aspect is characterized in that the assignment means comprises user interface means (Fig. 70) for attaching information representing parallel operation of works to the plurality of work standards as the composition targets, and makes a plurality of composition plans in consideration of the attached parallel operation and sends the composition plans to the output means.

The composition result can be preferably visually confirmed. In a still another preferred aspect of the present invention, the output means visually displays and outputs the total manhour of the work standards of each station.

When the total manhour of the work standards of each station is displayed in a form of a bar graph in units of stations as a composition result, confirmation is very easy.

For example, when a window of the display means is divided into a first display area and a second display area, and

the output means displays the bar graph of the total manhour of the work standards of each station in the first display area and the work standards belonging to the station in the second display area in units of stations such that the stations in the first display area and those in the second display area are correspondingly displayed, the

correspondence between a work standard of a station and a manhour can be confirmed at a glance.

According to still another preferred aspect of the present invention, the system is characterized in that the output means correspondingly displays the bar graph of the total manhour of the work standards of each station and the work standards belonging to the station.

According to still another preferred aspect of the present invention, the composition result is displayed as the bar graph of the total manhour in units of stations.

According to still another preferred aspect of the present invention, the composition result is displayed as a list of work standards put together in units of stations and belonging to each station. This makes it easy to confirm details of a work standard assigned to a station.

The composition must be easily corrected. The system preferably further comprises

user interface means for providing a user interface for further correcting the composition result output by the output means in units of stations, and

means for receiving editing information input by the user interface means and correcting the composition result.

Correction of a station is executed by, e.g., deleting the station, adding an arbitrary station to the station, exchanging an arbitrary work standard in the station with an arbitrary work standard in another station, adding an

arbitrary work standard to an arbitrary work standard in the station, or dividing a work standard belonging to the station into two stations.

In addition, correction of a station is executed by deleting the station, adding an arbitrary station to the station, exchanging an arbitrary work standard in the station with an arbitrary work standard in another station, adding an arbitrary work standard to an arbitrary work standard in the station, or dividing a work standard belonging to the station into two stations. In this case, a length of a bar graph of the station related to the correction may be corrected in accordance with a correction result.

A compositor must be limited to a specific person. According to still another preferred aspect of the present invention, a user interface window for authenticating a user who does composition is displayed.

According to still another preferred aspect of the present invention, a station to be added includes a check work standard.

A work standard having an excessively large manhour may be generated depending on the type of the work standard. The output means displays a total manhour of the work standards of each station in a form of a bar graph in units of stations.

For a bar graph of a station including a work standard having a manhour larger than the average manhour value of

the station or a value obtained by multiplying the pitch time (TP) by a predetermined value, a width of the bar graph is increased. This limits the height of the bar graph and makes it possible to efficiently use the display window. In addition, the necessity of assignment of a plurality of operators is explicitly indicated.

According to still another preferred aspect of the present invention, the system further comprises a database containing information related to a skill or experience of an operator, and the output means extracts the information related to the skill or experience of operators assigned in units of stations and displays the information together on a display window of the display means. Thus, the operators can be appropriately laid out to the stations.

The form of assignment of the present invention can have many variations. For example, in still another preferred aspect, the system is characterized in that the assignment means comprises code attachment means (Figs. 92 and 93) for causing a user to attach a single group code to a plurality of works in order to assign the plurality of works to a single station, and

the output means assigns work standards having the same group code to a station corresponding to the group code.

As another assignment method, the system is characterized in that the user interface means has a display unit for displaying a chart showing a priority order

relationship representing continuous and parallel operations of works, and

the code attachment means displays works having the same group code on the display unit so as to discriminate the works from works having another group code and works having no group code (Figs. 92 and 93).

As still another assignment method, the system is characterized in that each work standard as an assignment target has data representing continuous and parallel operations of works, and

the assignment means comprises

means for detecting that the user executes, for an arbitrary work standard, group designation to alter the continuous and parallel operations through the code attachment means, and

means for, when the detection is done, outputting a warning message or inhibiting the group designation (Fig. 94).

According to still another preferred aspect of the present invention, the detection means determines that the continuos and parallel operations are altered upon detecting that the user designates first and second groups so as to insert a work which should belong to the first group between two works belonging to the second group (Fig. 94).

The present invention can be preferably applied to a distributed client/server database system comprising a

server including the above-described work assignment file , and a plurality of clients each having the display means, condition input means, and assignment means.

According to still another preferred aspect of the present invention, the system further comprises simulation means (2850) for executing simulation of a production operation in the plurality of stations on the basis of the composition plan acquired from the assignment means, the simulation means being capable of transferring output data representing a condition and execution result of the simulation to the assignment means, and

the assignment means comprises averaging means (19006 - 19009) for changing assignment of each station on the basis of the output data acquired from the simulation means and data representing performance of each of the plurality of stations so as to satisfy the predetermined condition, thereby making a new composition plan in which unbalance in works between the stations is eliminated.

According to still another preferred aspect of the present invention, the method further comprises the simulation step of executing simulation of a production operation in the plurality of stations on the basis of the composition plan acquired in the assignment step, and

the assignment step comprises the averaging step of changing assignment of each station on the basis of a condition and execution result of the simulation, which are

acquired in the simulation step, and data representing performance of each of the plurality of stations so as to satisfy the predetermined condition, thereby making a new composition plan in which unbalance in works between the stations is eliminated.

The simulation step and the averaging step are preferably repeatedly executed until a desired simulation execution result is obtained.

In the work assignment system or method, when the simulation and averaging are repeatedly executed until a desired simulation execution result is obtained, the user can make a composition plan having a balanced actual load between the stations and capable of achieving the expected production quantity.

A preferred aspect for preventing a serious problem that the number of stations is too short to achieve the expected production quantity in actual production is, e.g., as follows.

More specifically, according to still another preferred aspect of the present invention, the simulation means comprises a user interface (Fig. 111) capable of setting a defective inclusion ratio of a part or material actually used for production of units in the plurality of stations, an operation error ratio of each station, yield of units and variation range of the yield related to the defective inclusion ratio and operation error ratio and

setting a value representing performance of each of the plurality of stations, and outputs a margin for works of each station, stagnation of fabricated products, and a quantity of completed nondefective products as the execution result of the simulation.

According to still another preferred aspect of the present invention, in making a new composition plan on the basis of the output data acquired from the simulation means and the value representing the performance of each of the plurality of stations, when a constraint condition for the continuous and/or parallel operation of assembly works as the plurality of work standards is preset by the user, the averaging means makes a composition plan satisfying the constraint condition.

According to still another preferred aspect of the present invention, in making a new composition plan on the basis of the output data acquired from the simulation means and the value representing the performance of each of the plurality of stations, when a group of a plurality of types of assembly works in assembly works as the plurality of work standards is preset by the user, the averaging means assigns the plurality of types of assembly works included in the group to a single station.

According to still another preferred aspect of the present invention, the assignment means comprises means for changing the number of stations on the basis of a time required

for works of each station, which is changed in consideration of the yield of units to be produced in the plurality of stations, and a stop time and average performance of each station.

According to still another preferred aspect of the present invention, the simulation means displays a display window including a user interface capable of setting a one-day working time of one crew as a set of a plurality of operators assigned to each station of a production line formed from the plurality of stations and changeably setting a stop time of the production line in units of days or time zones by inputting a probability distribution, average value, and variance value, and displays a one-day operation time of the crew in the display window in units of predetermined times as a result of setting of the one-day working time and stop time.

According to still another preferred aspect of the present invention, the simulation means displays a display window including a user interface capable of setting manhours of works assigned to each of the plurality of stations, a value representing performance of each station, and upper and lower limit values of a variation width of the value in units of time zones and changeably setting the value representing the performance in accordance with time and probability distribution within a range of the set predetermined variation width, calculates a one-day

production quantity of one crew as a set of a plurality of operators assigned to each station of a production line formed from the plurality of stations on the basis of the conditions set in the display window, and displays the calculated production quantity in the display window.

According to still another preferred aspect of the present invention, the simulation means can set, in a display window including a user interface, a defective inclusion ratio of a part or material actually used for production of units in the plurality of stations, yield of each station in accordance with an operation error ratio, and a station from which a defective product is to be excluded and can set the yield determined by the operation error ratio changeably in accordance with probability distribution in units of time zones, calculates a one-day production quantity of one crew as a set of a plurality of operators assigned to each station of a production line formed from the plurality of stations on the basis of the conditions set in the display window, and displays the calculated production quantity in the display window.

According to still another preferred aspect of the present invention, the simulation means comprises a user interface (Figs. 111 and 113) capable of setting, in addition to the plurality of stations included in the composition plan acquired from the assignment means, an assembly station for performing an assembly work independently of the stations

and/or a readjustment station for readjusting a defective product generated in the plurality of stations included in the composition plan and returning the readjusted defective product to the plurality of stations again as a nondefective product. In this case, a defective item of the defective product generated in the plurality of stations included in the composition plan, a station where the defective product is generated, and the readjustment station for returning the defective product after readjustment in accordance with the station where the defective product is generated can be preferably set in the user interface of the simulation means.

According to still another preferred aspect of the present invention, in addition to the operators in the composition included in the composition plan acquired from the assignment means, a support operator who supports the operators in the composition independently of the composition can be set in the user interface (Figs. 113, 114A, and 114B) of the simulation means, and

when the support operator is set as an alternate operator, an unaided assembly operator, a management operator, and a readjustment operator, the number of alternate operators to be transferred to a station of the composition can be changeably set in units of days in accordance with the probability distribution by setting the necessary number of support operators to be required and setting an attendance ratio of each operator in the

composition by setting the probability distribution, average value, and variance value, and an upper limit value of the number of readjustment operators can be changeably set in units of days by subtracting the number of alternate operators to be transferred to the station from the number of support operators.

According to still another preferred aspect of the present invention, the averaging means displays a display window (Figs. 117A, 117B, 118A and 118B) including a user interface capable of setting a value representing performance of each station as a condition for calculation of a target manhour of the station.

According to still another preferred aspect of the present invention, in making a new composition plan on the basis of the output data acquired from the simulation means and the value representing the performance of each of the plurality of stations, the averaging means exchanges works of the stations so as to make the manhour of each station close to a target manhour (Fig. 121) on the basis of a difference of the target manhour and a corresponding actual manhour of each station and the continuous and/or parallel operation preset for an assembly work as the work standard.

In this case, in exchanging the works of the stations, when a group of a plurality of types of assembly works in assembly works as the plurality of work standards is preset by the user, the averaging means assigns the plurality of

types of assembly works included in the group to a single station.

According to still another preferred aspect of the present invention, the assignment means can set and change the number of units to be excluded from a station during production by one crew as a set of a plurality of operators assigned to each station and set and change a stop time of a production line and an expected composition efficiency value, and comprises a user interface for calculating a time and the number of stations required for a work of each station on the basis of values of the set and changed number of units to be excluded, stop time, and expected composition efficiency and displaying a calculation result (Figs. 132-136).

According to still another preferred aspect, the work assignment system is characterized in that the system further comprises simulation means (2850) for executing simulation of a production operation in the plurality of stations on the basis of the composition plan acquired from the assignment means, the simulation means being capable of transferring output data representing a condition and execution result of the simulation to the assignment means, and the assignment means comprises averaging means for changing assignment of each station on the basis of the output data acquired from the simulation means and data representing performance of each of the plurality of stations so as to

satisfy the predetermined condition, thereby making a new composition plan in which unbalance in works between the stations is eliminated.

When this work assignment system is used, and the simulation means and averaging means are repeatedly executed until a desired simulation result is obtained, the user can easily make an optimum composition plan and largely decrease the work manhour.

The above object can also be achieved by the above composition method or a computer program storage medium for realizing the method by a computer system.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view showing the hardware configuration of an assembly standard information management system according to the first embodiment;

Fig. 2 is a view showing the relation structure of a representative model record, process (arrangement) record, and work standard record;

Fig. 3 is a view for explaining a window in which work standard data is to be input in the work standard system;

Fig. 4 is a view showing the linkage between master data files in the work standard system;

Fig. 5 is a flow chart for explaining the procedure of inputting work standard data;

Fig. 6 is a view for explaining a window for inputting data to the "applied model" field;

Fig. 7 is a view for explaining another method of inputting a model name to an applied model field 302;

Fig. 8 is a view for explaining reference input of data related to a part;

Fig. 9 is a view for explaining incremental search input of data related to a work;

Fig. 10 is a view for explaining incremental search input of data related to a work;

Fig. 11 is a view for explaining a window in which data related to a work is to be input;

Fig. 12 is a view for explaining reference input in inputting work data;

Fig. 13 is a view for explaining the reference input function in inputting "verb" in the work procedure;

Fig. 14 is a flow chart showing the control procedure in inputting data on the basis of the work procedure input window shown in Fig. 11;

Fig. 15 is a view for explaining an example of a plurality of input work procedures;

Fig. 16 is an explanatory view of the reference input

function in inputting a note;

Fig. 17 is an explanatory view of the reference input function in inputting a note;

Fig. 18 is an explanatory view of various menus for editing the work procedure itself;

Fig. 19 is a view for explaining operation of exchanging two work procedures;

Fig. 20 is a view for explaining operation of exchanging two work procedures;

Fig. 21 is an explanatory view of a menu for storing a created work;

Fig. 22 is a view showing a menu window for opening a work to be edited in editing the work standard;

Fig. 23 is a view for explaining a plurality of works opened by the menu shown in Fig. 22;

Fig. 24 is a view for explaining a menu window for executing an image editing function;

Fig. 25 is a view for explaining an input field to which an image to be attached is to be loaded;

Fig. 26 is a view showing an image attached to the work standard data;

Fig. 27 is a view showing a menu window for selecting a tool to edit an image;

Fig. 28 is a view for explaining positioning of a translation subsystem in the work standard creation system;

Fig. 29 is a view for explaining a start menu for

starting translation;

Fig. 30 is a view showing a window for selecting a work standard to be translated;

Fig. 31 is a view for explaining a state wherein the work standard to be translated and an English equivalent are displayed on opposite sides;

Fig. 32 is a view for explaining a state wherein the work standard to be translated and an English equivalent are displayed on opposite sides;

Fig. 33 is a view for explaining a menu window for activating playback of voice data attached to the work standard;

Fig. 34 is a view for explaining a menu window for activating voice data recording;

Fig. 35 is a view showing the storage positions of files in a work standard creation system 2800 and translation system 2803;

Fig. 36 is a view for explaining the file structure of a standard manhour setting system 2801 of the first embodiment in the form of blocks;

Fig. 37 is a view for explaining the data structure of a manhour setting file 3601;

Fig. 38 is a view for explaining the data structure of a standard data file 2804;

Fig. 39 is a view showing the directory structure in the standard data file 2804;

Fig. 40 is a view for explaining three routes of manhour setting in the standard manhour setting system 2801;

Fig. 41 is a view for explaining the outline of data load in the standard manhour setting system 2801;

Fig. 42 is a view for explaining the first route for setting the manhour on the basis of data from a standard material data file;

Fig. 43 is a view for explaining the second route for setting the manhour on the basis of data from an operation pattern data file;

Fig. 44 is a view showing a manhour setting file 3601;

Fig. 45 is a view for explaining the initial menu window of the standard manhour setting system 2801;

Fig. 46 is a view for explaining the window structure for defining the data range to be loaded in the standard manhour setting system 2801;

Fig. 47 is a view showing the list of work data defined by the window shown in Fig. 46;

Fig. 48 is a view for explaining the data load window;

Fig. 49 is a view for explaining that arbitrary works can be grouped by arbitrarily changing the hierarchical structure of directories in the standard manhour setting system 2801;

Fig. 50 is a view for explaining the file structure of the standard manhour setting system 2801;

Fig. 51 is a flow chart for explaining the control

procedure of the standard manhour setting system 2801;

Fig. 52 is a view for explaining a user interface window for selecting a "product" as a manhour setting target;

Fig. 53 is a view for explaining another user interface window for selecting a "product" as a manhour setting target;

Fig. 54 is a view for explaining the "model" selection window;

Fig. 55 is a view for explaining the dialog for selecting a "work" to be edited;

Fig. 56 is a view for explaining a work loaded by selection in Fig. 55;

Fig. 57 is a view for explaining the analysis material editing window;

Fig. 58 is a view for explaining a user interface window for selecting a work to be analyzed;

Fig. 59 is a view for explaining a user interface window for displaying representative WFs (Work Factors) that can be selected by the user;

Fig. 60 is a view showing a user interface window so as to explain the manhour definition of PU (pick up) operation;

Fig. 61 is a view showing a user interface window so as to explain the manhour definition of TURN (direction changing) operation;

Fig. 62 is a view for explaining a window for inquiring the change reason for the manhour of a specific work;

Fig. 63 is a view showing a window for displaying the change reason for the manhour;

Fig. 64 is a view for explaining the basic operation of a work assignment system 2802;

Fig. 65 is a view for explaining the file structure of the work assignment system 2802;

Fig. 66 is a view for schematically explaining the work composition in the standard manhour setting system 2801;

Fig. 67 is a view for explaining a window for displaying original data of simple division or parallel division in the standard manhour setting system 2801;

Fig. 68 is a view for explaining the work contents of stations divided by simple division;

Fig. 69 is a view for explaining a user interface window in further editing the workshop divided by simple division;

Fig. 70 is a view for explaining a user interface window for defining the parallel operation between works in parallel division;

Fig. 71 is a view for explaining a plurality of composition plans created by parallel division;

Fig. 72 is a view for explaining a user interface window in further editing composition plan 1 created by parallel division;

Fig. 73 is a view for explaining a user interface window in further editing composition plan 2 created by

parallel division;

Fig. 74 is a view for explaining a user interface window for defining a load target in loading data from the standard manhour setting system 2801 in the work assignment system 2802;

Fig. 75 is a view for explaining the reason why the data load range can be changed and defined in various ways in the work assignment system 2802;

Fig. 76 is a view for explaining a user interface window in opening an existing file in a composition table file 6400;

Fig. 77 is a view for explaining a state wherein the work data loaded in the memory of the work assignment system 2802 are displayed for each "target model";

Fig. 78 is a view for explaining a user interface window in adding a work in the standard manhour setting system 2801;

Fig. 79 is a flow chart for explaining the control procedure of simple division by the work assignment system 2802;

Fig. 80 is a view for explaining the states of five stations divided by simple division by the work assignment system 2802;

Fig. 81 is a view for explaining work division in the stations in the work assignment system 2802;

Fig. 82 is a view showing a state wherein a work having

a large manhour is assigned to station 2 to be parallel-operated in the workshop having five stations so as to explain work assignment;

Fig. 83 is a view for explaining the work division result in the stations in the work assignment system 2802;

Fig. 84 is a view for explaining a user interface window for station division in the work assignment system 2802;

Fig. 85 is a view for explaining a user interface window for adding or inserting a station in the work assignment system 2802;

Fig. 86 is a view for explaining a method of displaying a station to which a work having a large manhour is assigned by the work assignment system 2802;

Fig. 87 is a view for explaining an authentication window for authenticating a user who will compose works;

Fig. 88 is a block diagram for explaining the overall arrangement of a system according to a modification in which each subsystem has a standalone structure;

Fig. 89 is a view for explaining a state wherein operations of each of a plurality of works, and images and parameters corresponding to the respective operations are related to each other and stored;

Fig. 90 is a view showing images (images representing a continuous operation) continuously generated by designating parameters in accordance with the method shown

in Fig. 89;

Fig. 91 is a view showing a dialog box for inputting a component symbol in relation to Fig. 39;

Fig. 92 is a view showing a user interface window for grouping a plurality of works in composing works;

Fig. 93 is a view showing a user interface window for grouping a plurality of works in composing works;

Fig. 94 is a view showing a user interface window for grouping a plurality of works in composing works;

Fig. 95 is a flow chart for explaining a control procedure for work assignment as a modification to Fig. 79, i.e., a composition control procedure that the number of stations assigned works preferentially should not exceed the number of stations N_{ST};

Fig. 96 is a flow chart for explaining a control procedure for work assignment as another modification to Fig. 79, i.e., a composition control procedure for preferentially averaging the manhours of works assigned to stations;

Fig. 97 is a view showing the state of parallel-operated station 2 in the workshop of the example shown in Fig. 85;

Fig. 98A is a view schematically showing the arrangement of the assembly standard information management system;

Fig. 98B is a view showing the hardware configuration

of the assembly standard information management system;

Fig. 99A is a view schematically showing the arrangement of a simulation cooperating work assignment system;

Fig. 99B is a view showing the hardware configuration of the simulation cooperating work assignment system;

Fig. 100 is a view for explaining the basic operation of the work assignment system 2802;

Fig. 101 is a block diagram showing the relationship between the file structure of the work assignment system 2802 and a production simulation system 2850;

Fig. 102 is a view schematically showing work composition in the work assignment system 2802;

Fig. 103 is a view showing a user interface in which the parallel operability of works in the work assignment system 2802 is defined;

Fig. 104 is a view for explaining a user interface for designating a plurality of works to a group and putting them together into the group in composing the works;

Fig. 105 is a view showing a user interface for displaying work data loaded to the memory of the work assignment system 2802 and inputting composition conditions;

Fig. 106 is a view showing work data composed by the work assignment system 2802 and a menu for selecting an Excel output;

Fig. 107 is a view for explaining a user interface for

inputting an Excel output file name;

Fig. 108 is a view showing a menu for selecting a macro program for creating a file to which data to be transferred to the production simulation system 2850 is to be output;

Fig. 109 is a view for explaining a user interface for inputting data to be transferred to the production simulation system 2850;

Fig. 110 is a view for explaining the data to be transferred to the production simulation system 2850;

Fig. 111 is a view showing a simulation model of the production simulation system 2850;

Fig. 112 is a view for explaining data to be loaded and corrected by the production simulation system 2850;

Fig. 113 is a view for explaining a common readjustment station cell for a plurality of compositions;

Fig. 114A is a view for explaining the structure of the common readjustment station cell so as to explain the influence on the number of readjustment stations when an alternate operator is transferred in the composition;

Fig. 114B is a view for explaining the structure of the common readjustment station cell so as to explain the influence on the number of readjustment stations when an alternate operator is transferred in the composition;

Fig. 115 is a view for explaining performance data to be transferred from the production simulation system 2850 to the work assignment system 2802;

Fig. 116 is a view showing how to load and correct the performance data and execute PF-considered automatic averaging by the work assignment system 2802;

Figs. 117A and 117B are views showing the full graph display window before and after execution of the PF-considered automatic averaging processing;

Figs. 118A and 118B are views showing the "process PF input" window before and after execution of the PF-considered automatic averaging processing;

Fig. 119 is a view showing work movement (exchange) without altering the priority order;

Fig. 120 is a flow chart showing the control procedure of the PF-considered automatic averaging processing;

Fig. 121 is a view showing how to calculate the difference between the set PF value manhour and the actual assigned station manhour of each station;

Fig. 122 is a view for explaining the logic when the averaging target station is present after the exchange target station;

Fig. 123 is a view for explaining the logic when the averaging target station is present before the exchange target station;

Fig. 124 is a view showing a user interface for inputting a composition condition to compose works by changing the number of stations by the work assignment system 2802;

Fig. 125 is a view showing a result of a composition under the conditions input to the composition condition input user interface of the work assignment system 2802;

Fig. 126 is a view for explaining a user interface for inputting an Excel output file name;

Fig. 127 is a view showing a menu for selecting a macro program for creating a file to output data to be transferred to the production simulation system 2850;

Fig. 128 is a view for explaining a user interface for inputting data to be transferred to the production simulation system 2850;

Fig. 129 is a view for explaining the data to be transferred to the production simulation system 2850;

Fig. 130 is a view for explaining data to be loaded and corrected by the production simulation system 2850;

Fig. 131 is a view for explaining how to set the nonadjusted ratio, stop time, and composition efficiency for three months after the start of mass production;

Fig. 132 is a view showing how to input the composition conditions of the first month shown in Fig. 131 to the composition condition input user interface of the work assignment system 2802;

Fig. 133 is a view showing how to input the composition conditions of the second month shown in Fig. 131 to the composition condition input user interface of the work assignment system 2802;

Fig. 134 is a view showing how to input the composition conditions of the third month shown in Fig. 131 to the composition condition input user interface of the work assignment system 2802;

Fig. 135 is a view showing how to input the composition conditions of the fourth month shown in Fig. 131 to the composition condition input user interface of the work assignment system 2802;

Fig. 136 is a view showing a result of a composition under the conditions input to the composition condition input user interface of the work assignment system 2802;

Fig. 137 is a graph showing predictions of the cumulative number of products and the production time per unit for every 1/2 month of the three months based on a static prediction line;

Fig. 138 is a graph showing predictions of the cumulative number of products and the number of defective products for every 1/2 month of the three months based on a static prediction line;

Fig. 139 is a graph showing predictions of the cumulative number of products and the line stop time for every 1/2 month of the three months based on a static prediction line; and

Fig. 140 is a graph showing predictions of the cumulative number of products and the work time of each station for every 1/2 month of the three months based on a

static prediction line.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment in which the present invention is applied to a printer manufacturing process will be described below in detail with reference to the accompanying drawings.

[First Embodiment]

The overall system to be described in this embodiment is called an "assembly standard information management system". As shown in Fig. 28, this assembly standard information management system comprises three subsystems:

- work standard creation subsystem 2800,
- standard manhour setting subsystem 2801, and
- work assignment subsystem 2802

In the following explanation, these subsystems will be referred to as the work standard creation system 2800, standard manhour setting system 2801, and work assignment system 2802, respectively, for the descriptive convenience.

The work standard creation system 2800 creates (defines) a work standard (work standard data) for the standard manhour setting subsystem 2801 and work assignment subsystem 2802. In the work standard creation system 2800, the user is required to understand, for each work to be executed in the manufacturing process, a "verb" representing an operation of the work, an "object" that describes the target of the work, and some "comments" and also have

knowledge for the manufacturing process enough to sequentially describe the flow of the series of works.

The standard manhour setting system 2801 determines the standard manhour for the work standard created by the work standard creation system 2800.

The work assignment system 2802 determines composition (work composition) using the work standard created by the work standard creation system 2800.

<Overall Arrangement>

Figs. 1 and 98B show the hardware configuration of the assembly standard information management system of the first eembodiment. As shown in Fig. 1, this assembly standard information management system has a plurality of clients and one server (or a plurality of servers). The computer system of each client (to be referred to as a client system hereinafter) has, e.g.,

· OS: Windows95/98,
· DB connection software: ODBC driver for Oracle,
· communication network software: SQL-Net for Oracle,
· work standard creation system application program,
· standard manhour setting system application program, and
· work assignment system application program.

On the other hand, the server-side computer has a system configuration comprised of

· OS: Windows-NT server, and
· database: Oracle WorkGroup Server

On the assembly standard information management system constructed by a plurality of clients and one or a plurality of servers, three application programs or the "work standard creation system 2800", "standard manhour setting system 2801", and "work assignment system 2802" simultaneously or independently run in the so-called client/server environment.

Current computer hardware capable of realizing the general client/server environment can be applied to each of the internal hardware configurations of the server and clients of the assembly standard information management system, and a detailed description thereof will be omitted in this embodiment.

<Work Standard Creation System 2800>

The work standard creation system 2800 defines/creates master data to be used by the standard manhour setting system 2801 and work assignment system 2802.

A "work standard" represents a certain work unit in the manufacturing process. One work process (to be referred to as a process hereinafter) is formed from a plurality of work standards (or one work standard in some cases). To manufacture products of a model, a plurality of processes are defined for the products of the model, and one or a plurality of work standards are defined for each process, as shown in Fig. 2.

Referring to Fig. 2, process 1, process 2, ..., process

N are defined for a representative model A. A plurality of "work standards" can be defined for each process. Each work standard is input through an input window (either from the client terminal or the server terminal) as shown in Fig. 3.

As will be described later, in this embodiment, the basic work unit is called a "work standard" that is the base of work in the assembly process. However, the "assembly standard information management system" of this embodiment is finally a system for managing assembly of products in the factory and therefore is preferably capable of management not at the work standard level but at the product level.

As will be described later, one work is assigned one identifier (or directory). Sets of a plurality of work standards are classified using a hierarchical structure including "target model", "representative model" as the upper level thereof, and "genre" as the further upper level (e.g., a genre such as "printer" or "camera"). More specifically, the CRT window (display window) of the terminal displays menus:

· "create" menu, and
· master maintenance

When the user selects the "create" menu in this display window, a dialog box for inputting the name of "representative model" and the name of "process" appears on the screen of the display unit. In this window, the user inputs the name of "representative model" and the name of

"process". For example, assume that the input name of "representative model" is "BJC-4200", and the input name of "process" for the model "BJC-4200" is "total assembly". The application program will create a record "total assembly" under a record "BJC-4200" and create a plurality of work standard records under the record "total assembly".

The main menu of the application program includes "work standard", "edit",..., and the pull-down menu of the "work standard" menu includes "file new (N)".

The input window shown in Fig. 3 is displayed when the "file new (N)" is selected. That is, this application program allows the user to define a certain work of the representative model "BJC-4200" through the input window shown in Fig. 3. The user inputs the name of the work in a "work name" field 312.

In addition to the "work name" field 312, a window 300 shown in Fig. 3 has

· a field 302 to which the name of an "applied model" is to be input,

· an input field related to parts to be used in this "work" ("part number" field 303, "part name" field 304, and "quantity" field 305),

· an input field related to tools to be used in this "work" ("tool/treatment device/auxiliary material" field 306, "quantity" field 307, and "check etc." field 308),

· a field related to work standards as characteristic input

items of this application program ("number" field 309, "work standard" field 310, and "note" field 313), and

· a field 311 to which information related to a later revision/change of this "work" is input.

Fig. 4 shows files opened by this application program, which form a master data file group. Each master file will be described later.

Fig. 5 is a flow chart for explaining the input procedure for the input window shown in Fig. 3.

First, an input to the "applied model" field 302 is done in step S100 shown in Fig. 5.

The input in this step can be done in two ways: a direct input method by which the user directly inputs data to the field using a keyboard, and a menu input method by which an icon 301 is clicked to display a window with the list of a plurality of candidate names of the "applied models", as shown in Fig. 6, the user selects one of the displayed candidate names using a mouse or the like, and the selected name is input to the field 302. In the example shown in Fig. 7, the names of a plurality of "applied models" selected in the window shown in Fig. 6 are input to the field 302.

In step S200, the user inputs a desired note to the note column through the keyboard.

In step S300, the user inputs data related to parts or tools to a predetermined field through the keyboard while moving the cursor to an arbitrary position in the field using

the mouse.

A part number pairs with a part name. When one of them is input, a part data master file 40 (Fig. 4) is searched (so-called incremental search) using the input character sequence as a keyword, so all pairs of part numbers and part names having that keyword are displayed, as shown in Fig. 8. The user selects a pair from the displayed candidates, so the selected pair data is output to a predetermined field.

The method of incremental search used for the above search will be described with reference to Figs. 9 and 10.

In the incremental search, search is executed using characters input until the current time as a keyword to display candidates searched at the current time, and every time one more character is input, the candidates that have already been searched are narrowed down to only those matching the character sequence including the added character.

In the example shown in Fig. 9, when "GE" ("げ") is input to an input field (upper field), various words and phrases starting with "げ" are displayed in an output field (lower field) as candidates. Further, when "NZO" is input next to "げ", words and phrases starting with "現像 (GENZOU: developing)" are displayed in the output field as candidates, as shown in Fig. 10. That is, the candidates shown in Fig. 10 are narrowed down from those shown in Fig. 9. Note, that English translations corresponding to each of the Japanese

candidates are described, for easy understanding, in parentheses after the Japanese candidates in Figs. 9 and 10.

The description will be continued referring back to the flow chart shown in Fig. 5.

In step S400, pieces of information related to tools and the like are input to the fields 306, 307, and 308. For this data input as well, the direct input using the keyboard and the method of searching from the master file (tool file 60) are prepared, like the input in step S300.

In step S500, the user inputs details of a work standard for the work to be defined. The data input for definition of a work standard is the gist of the data input in the work standard creation system 2800, and a dedicated input window as shown in Fig. 11 is prepared. Details of step S500 are included in the control procedure shown in Fig. 14.

When the user double-clicks on an arbitrary part of the "work standard" field 310, the input window shown in Fig. 11 is displayed. When a work standard has already been input to the double-clicked position, i.e., when the user double-clicks on a portion where the name of an already input "work standard" is displayed, details of the already input work standard are displayed in the window shown in Fig. 11.

As shown in Fig. 11, one "work standard" comprises

- a "comment 1" field 1101,
- an "object" field 1102,
- a "comment 2" field 1103, and

· a "verb" field 1104.

"Operation" that defines one work is defined by the "verb" field 1104, and the target of the "operation" is defined by the "object" field 1102. The subject of the operation in the "verb" field 1104 is an operator. Hence, who is the operator need not be explicit.

"Comment 1" describes a comment about the "object". "Comment 2" describes a comment about the "verb". For example, if

"comment 1" = "at wwww position",

"object" = "xxxx",

"comment 2" = "become yyyy",

"verb" = "do zzzz"

are input, the user understands when the work standard is displayed that the operator should execute a work of "doing zzzz such that xxxx at wwww position becomes yyyy". Hence, appropriate and simple information must be input to the fields 1101 to 1104 assuming the above understanding by the operator. In other words, standardization is impossible if the user arbitrarily inputs data to the fields 1101 to 1104. To avoid this, the work standard creation system 2800 prepares in advance a standard database 70 already input in relation to "comment 1", a standard database 80 already input in relation to "object", a standard database 90 already input in relation to "comment 2", and a standard database 100 already input in relation to "verb", as shown in Fig. 4.

Additionally, when the user is going to input the respective items related to the work standard, the above-described incremental search method for the master databases corresponding to items that the user will input allows the user to execute reference input of already input data. Hence, defined standard terms can be input to the fields 1101 to 1104 regardless of the user.

The reference input operation related to the work standard will be described here with reference to Fig. 11 and the like.

Referring to Fig. 11, a field 1105 is divided into a reference instruction field 1105a and a work standard display field 1105b. "00*" is always displayed in the reference instruction field 1105a. The user who requires the reference input should double-click on the field 1105a.

An explanation will be done below by exemplifying a data input to the "comment 1" field 1101.

First, the user selects the field 1101 to notify the system that the user requires the data input of comment 1.

When the user double-clicks on "00*" in the field 1105a, the fields 1101 to 1104 shown in Fig. 11 disappear, and instead, a field 1201 in which a keyword for search of a reference item can be input and a field 1202 in which a plurality of reference item candidates are to be displayed are displayed, as shown in Fig. 12.

For example, as shown in Fig. 13, assume that the input

to the "comment 1" field 1101, "object" field 1102, and "comment 2" field 1103 is ended, and data "移動させる(IDOUSASERU: move)" is to be input to the "verb" field 1104 next. In this case, the user selects the "verb" field 1104 in the input window shown in Fig. 11 and double-clicks on "00*" in the field 1105a. Then, the window changes to that shown in Fig. 13.

The user does not know the standard verb for the operation "移動させる(IDOUSASERU: move)" but knows that at least the character "動 (DOU: move)" must be used. Referring to Fig. 13, the user inputs "動 (DOU: move)" to the field 1201. The system searches the "verb" master database file 100 for all verb data having the character "動 (DOU: move)". In the example shown in Fig. 13, verbs

"移動させる(IDOUSASERU: move)",

"往復動作させる(OUFUKUDOUSASASERU: reciprocally move),

and

"動かす(UGOKASU: move)

are stored in the database 100. These words are searched for the displayed in the field 1202. The user selects "移動させる(IDOUSASERU: move)" in the field 1201 through this window. When "移動させる(IDOUSASERU: move)" is selected in the window shown in Fig. 13, and then, the ENTER key of the keyboard is pressed, the window returns to the window shown in Fig. 11, where "移動させる(IDOUSASERU: move)" is displayed in the field 1104.

The reference input is used for the input to all the fields 1101 to 1104 (steps S506 to S512 in Fig. 14).

A plurality of work standards are displayed in the field 1105 except the field 1105a. Fig. 15 shows that four work standards (procedures 01 to 04) are input.

Each of the work standards can be assigned a note, as shown in Fig. 16.

A note is input to a field 1106. The reference input function can also be used for the input of a note. More specifically, when the user wants to add a note to the already defined work standard 01 (displayed in the field 1105b), the user selects the field 1105b using the mouse and then selects the field 1106 using the mouse. If the user individually requires the reference input, the user double-clicks on "00*" in the field 1105a. Then, a field 1107 changes to a keyword input field 1601 and reference item display field 1602, as shown in Fig. 16. For example, when the user wants to refer to a note including a word "注意 (CHUI: note)", the user inputs "注意 (CHUI: note)" to the field 1601. The work standard creation system 2800 searches the note database 50 (Fig. 4) and displays all notes including "注意 (CHUI: note)" in the field 1602, as shown in Fig. 16. When the user selects a desired note using the mouse and presses the ENTER key, the note is displayed in the field 1107, as shown in Fig. 17.

In this system, an input data editing function is prepared as processing in step S514 (Fig. 14).

In this editing function, to individually change a character in data representing work contents, the number of the work standard to be changed is selected in the field 1107, and the work standard is double-clicked. Then, the data of "comment 1", "object", "comment 2", and "verb" assigned to the procedure are displayed in the fields 1101 to 1104, respectively, and a note corresponding to the procedure is displayed in the field 1106. The user individually corrects the data in each field.

A method of editing one unit of the work standard will be described next with reference to Fig. 18. Editing each unit of the work standard means an operation of deleting one work standard, an operation of setting the same work standard to another sequential position, or an operation of setting (inserting) a "free" work standard between two arbitrary work standards adjacent to each other.

A menu 1802 shown in Fig. 18 is opened, for example, when the right mouse button of the client is clicked.

In this menu 1802, editing functions including

· cut, copy, paste, add, delete, and

· undo, revise (change), revise (delete)

are set.

To "delete" a work standard, the target work standard is selected, and the "delete" menu is selected. To copy the contents of a work standard, the "copy" menu is selected. To paste work standard data copied in the work memory to a

desired sequential position, the sequential position is selected, and the "paste" menu is selected. With this "paste" operation, the contents of the work standard at the paste position are popped down.

To set a free work standard to the position of sequence 01, procedure 01 is selected in Fig. 18, and the "add" menu is selected. In the example shown in Fig. 18, work standards 01 to 03 sequentially move to procedure positions 02 to 04, and a free procedure is set to procedure position 01.

These various editing functions for "work", which are prepared in the work standard creation system 2800, are commonly used as editing functions in the standard manhour setting system 2801 or work assignment system 2802 to be described later. The mouse operation for these editing functions is also common. The operation is simplified by this common scheme.

A function of changing the order of a plurality of already input work standards will be described with reference to Figs. 18 to 20.

Assume that three procedures or works:

· 01: confirm 100V system

· 02: wind AV cord

· 03: set CRG holder

are currently set as work standards, as shown in Fig. 18, and the user wants to exchange procedure 01 with procedure 02. In this case, the user selects procedure 01 and selects

the "cut" menu. With the series of operations, the contents of procedure 01 are saved in the work memory, and the contents of procedures 02 and 03 are sequentially shifted to procedures 01 and 02, as shown in Fig. 20. Next, the operator selects the procedure to be exchanged (procedure 02 in the example shown in Fig. 20) and selects the "paste" menu. As shown in Fig. 19, the contents of all procedures from procedure position 02 are sequentially popped down to the lower procedures, and simultaneously, the contents of original procedure 01, which are saved in the work memory, are pasted to procedure position 02.

With the above operation, the input or editing in steps S502 to S514 in Fig. 14 is ended. The user presses an OK button 1108 to indicate that the input of work method is ended.

When the OK button 1108 is pressed, the window returns to the window shown in Fig. 3. In the window shown in Fig. 3, especially, the plurality of set work standards would be displayed in the field 310, and the note would be displayed in the field 313.

The user gives a "work name" as a standard work to the plurality of work standards set in the field 310. That is, the user inputs the work name to the field 312.

When setting of one standard work is ended, the user selects "save" in the menu shown in Fig. 21.

<Editing of Work Contents>... Work Standard Creation System 2800

To edit work contents, "open" in the "work standard" menu is selected (Fig. 22), and the work standard to be edited is selected using the mouse (Fig. 23). When an OK icon 2301 is clicked, the selected work is displayed (e.g., as shown in Fig. 3). Editing is done through almost the same window as in the input.

<Input of Graphic Data>... Work Standard Creation System 2800

The assembly information management system can display a process set by the work assignment system 2802 at the site of work (client side). For example, when window display shown in Fig. 3 is done at the site of work, the operator can see the display and confirm the work contents, notes, tools, and parts at a glance. In this system, an image can be attached to each work standard in addition to the above character information for the work.

Fig. 24 shows a window for inputting graphic data. This window is displayed when the user selects the "illustration" menu (menu on the right side of the "edit" menu") in executing the application program of the work standard creation system 2800, and a graphic pattern displayed in accordance with the selection operation can be edited. The image file to be edited is created in advance by a presentation application program PowerPoint (available from Microsoft) or Canvas and stored as a graphic file 120.

When the user selects the "display" submenu in the "illustration" menu, an illustration display column 2500

(Fig. 25) is displayed. The user inputs the name of a file to be attached to a "file name" field 2501 in the display column 2500. In accordance with the input, the system searches for the file whose name is input to the "file name" field 2501 and displays it in the column 2500. In the example shown in Fig. 26, an image file "so-09.wmf" is displayed at a position corresponding to the illustration display column 2500 shown in Fig. 25 as the result of user's file name input operation.

To edit the image, the authoring tool for editing is selected, and then, the "edit" menu is clicked, as shown in Fig. 27. After the end of editing, the update result can be saved by clicking on an "update" icon 2602 (Fig. 26).

In the above example, the image is a still image in the BMP format. However, it may be a moving image compressed by MPEG.

A so-called animation image may be stored in the graphic file 120 (Fig. 4). In this case, each animation image is stored with predetermined parameters unique to the operation of the image.

In assigning parameters unique to an operation to the operation in advance, if operations are, e.g.,"screw", "rotate", and "open", for example, pieces of parameter information:

· operation: screw → parameter values: direction of screwing, moving distance, torque amount,...

· operation: rotate → parameter values: direction of rotation, moving distance,...

· operation: open → parameter values: direction of opening, moving distance, weight,...

are registered.

An image with such parameters is registered in the graphic file 120 by combining the directory name, operation (verb) name, and parameters for each animation image, as shown in Fig. 89.

When the graphic file 120 stored in the state as shown in Fig. 89 is present, and in this state, a work standard is defined in the window shown in Fig. 11, the value of a parameter to be set for the work standard is written in the "comment 1" or "comment 2" field in units of operations of the work standard. The system compares each operation with each of the verbs and the parameter value in the comment with each of the parameter values registered in the graphic file and assigns the directory of an animation image having matching operation and parameter to the work standard. The directory name of the assigned animation image is displayed in a field 2601.

Fig. 90 shows an example in which three work standards:

· screw A.

· rotate main body, and

· open cover

are defined for a product. In this example, two continuous

still images (animation images) are assigned to each operation. In other words, when the parameters of the respective operations are assigned to the three work standards, a series of images A1 → A2 → B1 → B2 → C1 → C2 are continuously displayed, so a work instruction easy to understand can be easily created. In addition, only by designating an operation name and parameter, an animation image corresponding to the work parameter can be designated.

When an animation image is employed, no photorealistic image need be prepared, so work standard data can be created at the initial preparation stage before the start of operation of the factory. For creation of work standard data at the initial stage, automatic image data designation using parameters is preferable.

<Translation>... Translation System

Assembly work is not always done only in Japan. This system for standardizing assembly work expects operation not only in Japan but also in many foreign factories (for example, factories in the English-speaking zone and Thai-speaking zone). For this purpose, the work standard creation system 2800 has a translation system 2803.

As shown in Fig. 28, the translation system 2803 downloads master data created by the work standard creation system 2800 from the work standard creation system 2800, and after translation, uploads the translated master data to the work standard creation system 2800, as shown in Fig. 28.

The menu of the translation system 2803 includes "upload" for uploading work standard data to the master file, "work standard download" for downloading work standard data from the master file, and "work standard translation" for starting translation, as shown in Fig. 29. Icons for switching the translation target between work standard and master data are also prepared.

For example, when work standard data is selected as a translation target, a window 3000 as shown in Fig. 30 is displayed to prompt the user to input a "representative model name" (3001) and "process name" (3002).

With a check box 3003, display of the entire text, display of only an untranslated portion, or display of only an error portion of translation is selected as the range of the display target. With a check box 3004, the translation language can be selected. When the user clicks on a "display" icon button 3007, the names of all works having the model name input to the "representative model name" field 3001 and the process name input to the "process name" field 3002 are displayed in a display area 3005.

If the user wants to translate all works in this display state, he/she clicks on a "select all" button 3006 to select all works. If the user wants to translate some works, he/she selects the names of works to be translated in the area 3005 using the mouse or the like and clicks on a "translate" button 3008. In accordance with clicking by the user, translation

starts. When translation by the translation system 2803 is ended, "×" in the "auto-translation" column on the right side of the translated work name in the area 3005 changes to "○".

For work names (field 312 in Fig. 3), part names (field 304), tools and the like (field 306), and notes and the like (field 313) of text data registered in the master data file, the translation system 2803 converts the Japanese to the English using a dictionary. Since this is conversion from words to words, a dictionary (table) is preferably used. Especially, since this work standard creation system 2800 uses the incremental search in inputting data, standard terms are used, and arbitrary word selection is eliminated, as described above. For this reason, the conversion accuracy improves.

However, the work procedure (field 310) is manually input by the user. This is because the language structure of the Japanese is largely different from that of the English, and data (especially comment 1 and comment 2) constructing the work standard with high arbitrariness (i.e., close to a natural language) is unsuitable to conversion using a table.

To prevent a bulky system configuration, the translation system 2803 does not employ a translation method using language analysis (semantic analysis). A reason for this is as follows. In work management, many natural

language texts are not always input. Translation is necessary only on a limited occasion when a work is to be newly defined, or work contents are to be changed, so machine translation that is expensive and time-consuming for maintenance is inappropriate. Between European languages (e.g., English and German) having relatively similar language structures, machine translation is appropriate even for the contents of work standards.

Another reason why the advanced machine translation is not employed between, e.g., Japanese and English is the problem of operating system. That is, there is currently no operating system depending on two languages. For example, the WINDOWS of Japanese version and WINDOWS of English version do not simultaneously run for the work standard creation system 2800.

In addition, currently, a work standard is created using one language (e.g., on the Japanese side), and only software that runs on the WINDOWS (or WINDOWS NT) of Japanese version has the function of converting the Japanese text to English. In other words, converting various terms (text data) created by the work management system to the language of another country depends on the function of the language of the operating system based on the official language of that country. For this reason, conversion using a table is most reliable for easy translation to the language of that country.

As described above, this translation system uses word conversion using a table (table dictionary) for a word in a work standard. Additionally, if the table dictionary also stores a converted word for a phrase longer than a word, the phrase is replaced with the converted word. In principle, a word in a work standard, which cannot be completely translated even using the table dictionary, is manually corrected.

To confirm the translation result for a work, the name of the work is selected in the display area 3005, and the "display" button 3007 is clicked. Then, a window as shown in Fig. 31 is displayed. Whether the translation has been appropriate is determined by checking the translation result. To verify the adaptability between a specific English word and a corresponding Japanese (adaptability of translation result), the word portion is double-clicked to display a correction window 3200 as shown in Fig. 32.

All work standards of the work with this work name are displayed in Japanese in an area 3202. English work standards corresponding to these Japanese work standards are displayed in an area 3204. In the example shown in Fig. 32, work standard 01 is selected. This selected work standard 01 is displayed in Japanese in an area 3201, and an English equivalent of procedure 01 is displayed in an area 3203. The English text is corrected in the area 3202.

<Voice Input>... Translation System

Data input in the work standard creation system 2800 and, more particularly, translation of work standards into the language of another country is done by word conversion and manual input. Manually inputting a translated text requires the user to have both an ability of translation and an ability of high-speed input using the keyboard. Since it may be difficult to ensure an operator who has both the abilities in that country, the translation operation and input operation are separated. That is, a translation result is recorded by voice input, and the data is input in playing back the recorded voice.

To input (record) voice, a work standard to which input voice is to be attached is selected, and the "new" menu in the voice menu (Fig. 33) of the translation system application program is selected, thereby displaying a window shown in Fig. 34 overlapping the window shown in Fig. 31. When the recording button (●) in the window shown in Fig. 34 is clicked, recording starts. The voice sampling rate and the like are set in advance. To end recording, the ■ button is clicked. To save the recorded voice, "save" in the "work standard" menu is selected.

Fig. 35 shows the storage positions of files saved in the work standard creation system 2800 and translation system 2803.

Both the work standard creation system 2800 and translation system 2803 can process not only voice and image

files but also, e.g., MOVIE files by QUICKTIME.

In the work standard creation system 2800, a plurality of files temporarily registered, as shown in Fig. 35, can reproduced together (including voice and images). For example, when one or a plurality of work standards are selected in the window shown in Fig. 23, and display in the "illustration" menu or "playback" in the voice menu is selected, the images/voices of the work standards are displayed/played back in the defined order.

The voice and image are preferably synchronized. A QUICKTIME file or MOVIE file can easily synchronize voice and image. The work standard creation system 2800 also proposes to superpose CG data of an arrow or the like on still image data. During voice playback of a work, the arrow can visually indicate the operator in detail which work portion is being mentioned.

The work assignment system 2802 to be described later composes the work standard data created by the work standard creation system 2800, thereby assigning each work to a desired workshop. The result is reflected to a composition table file 6400 to be described later. The composition table file 6400 is uploaded to the work standard creation system 2800.

More specifically, the work standard creation system 2800 can input works in the composition order corresponding to actual assembly workshops from the work assignment system

2802 and open the works. The uploaded file has voice data and image data attached by the work standard creation system 2800. When the voice/image playback function of the work standard creation system 2800 is exploited at the actual site of assembly, the work contents can be instructed to the operator in detail by voice and image.

<Effect of Work Standard Creation System 2800>

According to the work standard creation system 2800 of the above-described embodiment, the following effects can be obtained.

AD-1: The work standard creation system 2800 describes a work related to a work standard by an operation phrase representing an operation of the work, an object phrase representing the target of the operation, and a comment phrase representing auxiliary information related to the operation or object. Hence, all work standards are standardized by the elements including the operation, object, and comment phrases.

AD-2: The work standard creation system 2800 is preferably built under a client/server computer system. When a common memory (or disk) connected to the subsystems to store or read out work standards is prepared, a client/server distribution system for assembly information management is provided.

AD-3: In this embodiment, the translation system 2803 can translate the operation, object, and comment phrases in

each record of the standard manhour database into a predetermined language such that the system can operate in a country with a different language.

AD-4: For translation by the translation system 2803, a translation method using matching to a dictionary is employed in consideration of easiness.

AD-5: Image data or voice data can be attached to a work standard.

AD-6: Since not only a photorealistic image but also CG data or animation image can be used as image data, work standard data can be created at the initial stage quite before the actual operation of the factory.

<Standard Manhour Setting System 2801>

The standard manhour setting system 2801 is a system for determining the standard manhour of a desired work and is connected to the work standard creation system 2800. More specifically, as shown in Fig. 28, the standard manhour setting system 2801 and work standard creation system 2800 share master data and the like. Determination of the standard manhour by the standard manhour setting system 2801 is preferably done in the form of so-called batch processing. Hence, after master data including work standard data as the determination target is downloaded to the standard manhour setting system 2801, the standard manhour setting system 2801 determines the standard manhour.

The above-described work standard creation system 2800

does not input manhour data. The work standard creation system 2800 does not give a manhour value to a standard work because, in the standard work created by the work standard creation system 2800, the manhour value given to each work must not vary depending on the person or day. The idea is that the manhour value is determined by the user who will compose works at the time of composition. To standardize the manhour value, the standard manhour setting system 2801 uses standard data as basic manhour data.

As shown in Fig. 28 or 36, the standard manhour setting system 2801 outputs a manhour setting file 3601 using, as reference files, a standard data (to be referred to as CS (C. Standard data) hereinafter) file 2804 and operation pattern data file 2806.

Fig. 37 shows the data structure of the manhour setting file 3601. The manhour setting file 3601 shown in Fig. 37 has records in units of element works and has the names of the element works, the frequencies of the element works, the manhours of the element works (unit: RU), the values of "CS", and the values of "set conditions". More specifically, the value of the directory of a data file containing the contents of a set condition given to the work is stored in the "set condition" field. The value of the root directory of the set condition data file is stored in the "CS" field.

Fig. 38 shows the data structure of the standard data file 2804. Each record of the standard data file 2804 is

called a standard material. As shown in Fig. 38, each record of the standard data file 2804 has a "comment 1" field, "object" field, "comment 2" field, "verb" field, and "set condition" field. The "comment 1", "object", "comment 2", and "verb" fields in the standard data file 2804 are the same as those in the work standard creation system 2800. Set condition data will be described later.

Fig. 39 shows examples of the data structure in the standard data file 2804. Referring to Fig. 39, standard material data 3901 of an element work has directories "SPG3/T133/M11/0", and standard material data 3902 of another element work has directories "ASHD/T11222/T1111".

The operation pattern data file 2806 has the same data structure as that of the CS data file 2804. More specifically, work data contained in the operation pattern data file 2806 include data as shown in Fig. 38, which are related to works actually executed in the past. Only the difference from the standard data file 2804 is whether the work is recognized as a "standard".

As described with reference to Fig. 2, there are an infinite number of works related to manufacturing a device (printer) as a product. However, as described with reference to Figs. 1 to 35, the work standard creation system 2800 can easily define a number of element works as "work standards" each constituted by

· two comments,

· object, and

· verb

Especially, as shown in Fig. 2, work standards are classified into processes, and processes are classified into models. In other words, models, processes, and works have tree structures, as shown in Fig. 2.

On the other hand, the work assignment system to be described later changes the composition of element works in consideration of the manhour. That is, the work standard creation system 2800 defines works, and the standard manhour setting system 2801 sets the manhour such that the composing operation by the work assignment system 2802 is facilitated.

The work standard creation system 2800, standard manhour setting system 2801, and work assignment system 2802 commonly have work elements with identifiers. However, since the identifiers themselves do not make the user remember the work contents, the master files cannot be searched using the identifiers of work elements (standard works). Hence, this system is designed to be able to execute multi-keyword searching using, as keywords, a total of four phrases, i.e., two comments, object, and verb common to all the systems.

To give a manhour to each work created by the work standard creation system 2800 in advance, the standard manhour setting system 2801 searches the standard material data file 2804 using the total of four phrases, i.e., two

comments, object, and verb (the combination of these four keywords will be referred to as a "work identification multi-keyword" in this specification) and gives manhour data (the above-described "manhour" and "set condition") attached to the found standard data to each work data of data created by the work standard creation system 2800.

The outline of this procedure is shown as a flow chart "search of manhour standard material" on the left side of Fig. 40. Referring to this flow chart, work standard data created by the work standard creation system 2800 is loaded in step S4001. In step S4002, it is determined for each work whether data having work identification keywords matching (or partially matching or ambiguously matching) the work identification multi-keyword of the work is present in the standard material data file 2804, and if so, manhour data HS of a record in the standard material data file is assigned to the work standard data. For example, work data loaded from the work standard creation system 2800 is represented by X, and a work identification multi-keyword of the data X is represented by KW. In step S4004, the user has a chance to confirm whether the assigned manhour data HS is appropriate.

On the other hand, it is determined in step S4002 that the work identification multi-keyword KW of the work data X is not present in the standard material data file 2804, a record having the work identification multi-keyword KW is searched for from the operation pattern data file 2806 in

step S4010.

As described above, the operation pattern data file 2806 has the same data structure as that of the standard material data file 2804. The difference between the two files is that data in the operation pattern data file is not a standard but at least has manhour data set in the past. When such work data is present in the operation pattern data file 2806, manhour data HP set for the work data is assigned to the target work. In step S4014, the user is given a chance to confirm whether the manhour data HP is correct.

That is, in the flow chart "search of manhour standard material" on the left side of Fig. 40 and the flow chart "search of operation pattern" at the central portion of Fig. 40, manhour data is automatically searched from standard material data or past data and assigned without intervention of the user. However, there must be works unsuitable to automatic assignment. The flow chart on the right side of Fig. 40 explains a user's procedure of directly setting manhour data to a work unsuitable to automatic assignment by the user.

As is apparent from Fig. 36, the standard manhour setting system 2801 has three routes to set manhour data. Referring to Fig. 40, the route using the standard material data file 2804 is called a "first route", the route using the operation pattern data file 2806 is called a "second route", and the route in which the user directly analyzes

a work and assigns manhour data is called a "third route" for the descriptive convenience.

The work or procedure in Fig. 40 will be described using a detailed example shown in Figs. 41 to 44. Fig. 41 is a view for explaining for explaining data load in step S4001 of Fig. 40. Fig. 42 is a view for explaining the operation of the first route in detail. Fig. 43 is a view for explaining the operation of the second route. Fig. 44 is a view showing a detailed example of the final manhour setting file 3601 obtained by the operation in Figs. 41 and 42.

As for the operations shown in Fig. 40, the operation of the first, second, or third route is performed every time a work data file is downloaded from the work standard creation system 2800, i.e., every record of the work data file. However, Figs. 41 to 44 show the operations as if the operation of the first, second, or third route were performed at once for all the downloaded files, for the illustrative convenience.

Referring to Fig. 41, the manhour setting file 3601 before data load has the data structure shown in Fig. 37. When data created by the work standard creation system 2800 is loaded to the manhour setting file 3601, the "comment 1" field, "object" field, "comment 2" field, and "verb" field in the work data file are loaded as an "element work name". Since the work data file does not contain manhour data, the

manhour setting file 3601 has no manhour data at the stage of data load in Fig. 41.

For the descriptive convenience, the Japanese texts in the "element work name" field of the manhour setting file 3601 shown in Fig. 41 are not translated to English, and English equivalents of these texts are indicated by *1 to *5 in the margin of Fig. 41. This aims at indicating that when data in the respective columns of the table shown on the lower side of Fig. 41, which are created by the work standard creation system 2800, are directly loaded in this order, and the data in the row direction (horizontal direction) of the columns are connected, these data form significant Japanese texts in that word order in the "element work name" field.

Although each "element work name" shown in Fig. 42 and the like is illustrated as a series of text data for the illustrative convenience, the "element work name" field is actually separated into the "comment 1" field, "object" field, "comment 2" field, and "verb" field.

Fig. 42 explains the first route. For example, when the first record is downloaded from the work standard creation system 2800, standard data having the keyword KW "set load spring in treatment device for attaching load spring" is searched from the standard material data file 2804.

The symbol "*" in the keyword formula shown in Fig. 42

and the like will be described here.

The "*" is a symbol representing a wild card and can have an arbitrary value. Data shown in the first record of the standard material data file 2804 shown in Fig. 42 are

- comment 1 = *
- object = *"バネを (BANEO: spring)"
- comment 2 = *"に (NI: to)"
- verb = "組み込む (KUMIKOMU: set)"

That is, since the "comment 1" field of the first record is designated to "*", it matches any text data contained in the "comment 1" field of the "element work name" field as the work data in the manhour setting file. In a similar manner, for the "object", any word including "バネを (BANEO: spring)" can match in all records. For the "comment 2", any word including "に (NI: to)" can match in all records. For the "verb", any word including "組み込む (KUMIKOMU: set)" can match in all records.

In the example shown in Fig. 42, the first record in the manhour setting file 3601 matches the first record in the standard material data file 2804, which has

"＊, ＊バネを (BANEO: spring), ＊に (NI: to), 組み込む (KUMIKOMU: set)", and

the second record having

"＊, ＊を (O), ＊に (NI: to), 組み込む (KUMIKOMU: set)"

In the standard manhour setting system 2801, when a record matches two or more records, it is determined that

the record matches a record having the highest degree of matching. The degree of matching is obtained with reference to the number of characters except the wild card. In the example shown in Fig. 42, the first record in the standard material data file 2804 contains more matching text data than the second record. Hence, it is determined that the degree of matching is higher for the first record in the standard material data file 2804 than for the second record. It is finally determined that the record matches not the second record but the first record.

The first record in the standard material data file 2804 has a time value "41 RU" as a manhour, so "41" is set in the "manhour" field of the first record of the manhour setting file 3601. In addition, the first record in the standard material data file 2804 has ""SPG3/T133/M11/0" as "manhour standard material" data. The root directory of manhour information is "SPG3", and the sub-directories are "T133/M11/0". Hence, "SPG3" is stored in the "CS" field of the first record in the manhour setting file 3601, and data "T133/M11/0" is stored in the "set condition" field.

When this system is used in a non-Japanese-speaking zone, the "degree of matching" is determined with reference to the number of matching words.

For the above search in the standard manhour setting system 2801, perfect matching or partial matching by words or phrases except the wild card symbol are employed, and one

candidate is always employed in principle. However, a plurality of candidates may be displayed in descending order of degrees of matching, and the user may finally select a candidate.

When similar checking is performed for the remaining four records in the manhour setting file 3601, the second record matches no record in the standard material data file 2804, the third records matches the second record in the standard material data file 2804, the fourth record matches no record in the standard material data file 2804, and the fifth record matches the third record in the standard material data file 2804.

Hence, for the third work data in the manhour setting file 3601, which matches a record, "37" is assigned as a "manhour", "ASHD" is assigned as a "CS", and "T11222/T1111" is assigned as a "set condition". For the fifth work data, "16" is assigned as a "manhour", "PUMB" is assigned as a "CS", and "T2111/T111111" is assigned as a "set condition". Thus, the manhour setting file 3601 is tentatively created as shown in Fig. 42 in accordance with the manhour data setting procedure by the first route.

On the other hand, for the second and fourth work data that do not match any record by the first route, the procedure of the second route is executed as shown in Fig. 43. The text data of "element work names" of the second and fourth work data and the "comment 1", "object", "comment 2", and "verb"

in the operation pattern data file 2806 are searched.

In the example shown in Fig. 43, the second and fourth work data match the first and second records in the operation pattern data file 2806, respectively. Hence, the values ("/GET-50E/M-10E" and "/GET-50E/M-10E") of the "operation pattern" fields of the first and second records in the operation pattern data file 2806 are stored in the "set condition" fields of the second and fourth records in the setting file 3601. In this case, the records do not match the standard material data file, no value is written in the "CS" fields in the setting file 3601. Thus, the operation of the second route is ended.

In this way, the manhour setting file 3601 is set as shown in Fig. 44 by the operations of the first and second routes.

The operation of the third route is performed when the standard manhour can be determined by neither the first route nor the second route. In the third route, the standard manhour is determined by directly analyzing the WF (Work Factor).

The overall operation of the standard manhour setting system 2801 has been described above. Details of the operation of the standard manhour setting system 2801 will be described below.

<Data Load>... Standard Manhour Setting System

Fig. 45 shows the initial menu window displayed when

the standard manhour setting system 2801 is activated. In this menu, six main menus:

· data load (icon 4501),
· standard manhour processing (icon 4502),
· standard material creation (icon 4503),
· master data maintenance,
· environment setup, and
· analysis material editing (icon 4504)

can be selected.

Data load is necessary before determination of the standard manhour. When the user selects the data load menu 4501, a window as shown in Fig. 46 is displayed.

Referring to Fig. 46, the window is roughly divided into to areas. A field 4601 on the left side indicates product symbols created by the work standard creation system 2800, i.e., product numbers (or the names of "representative models") that can be downloaded to the manhour determination system.

Fields 4602 to 4605 on the right side indicate work names downloaded from the work standard creation system 2800 in the past. More specifically, the field 4602 indicates the names of "work standards" downloaded by the standard manhour setting system 2801, the field 4603 indicates the "product symbols" of the respective "work standards", the field 6404 indicates the "names" of the respective "work standards", and the field 4605 indicates download dates, i.e., "load

dates".

One or a plurality of "product numbers" to be loaded (downloaded) are selected from the field 4601 using the mouse. To given a name different from that set by the work standard creation system 2800 to the product to be downloaded, the product number of the product to be named is designated in the field 4601, and the "name" is input to a field 4601. Data load is started by selecting the product to be loaded with the mouse, clicking on a "select" button 4611, and clicking on an "OK" icon 4612.

When the user clicks on the "OK" icon 4612, work name data is loaded to the memory of the standard manhour setting system 2801, and a window as shown in Fig. 47 is displayed.

The window shown in Fig. 47 displays the list of works present on the memory of the standard manhour setting system 2801. A work downloaded previously can be discriminated from the current download data by referring to a previous load date field 4703.

Since the standard manhour setting system 2801 is separated from the work standard creation system 2800, works or work groups to be considered by the standard manhour setting system 2801 itself are present independently of works or work groups set by the work standard creation system 2800. In the standard manhour setting system 2801, one work (or work group) is independently recomposed by the standard manhour setting system 2801 as another "component".

The component newly set by the standard manhour setting system 2801 is discriminated from other components by a "component symbol". To create a component, the names of a plurality of works to be set in the component are selected in a field 4701, the "component symbol set" menu in the edit menu is selected, and a component symbol (field 9101) and name (field 9102) are input through a window as shown in Fig. 91. Thus, the component symbol is assigned to a field 4702 in Fig. 47 in correspondence with the selected work names.

Referring to Fig. 47, a flag 4705a represents the state of work standard data. When the value of this flag is "N", it represents that the work standard is newly created. When the value is "C", it represents that the work standard is previously loaded to the standard manhour setting system 2801 and then changed on the standard manhour setting system 2801 side. When the value is "D", it represents that the work standard is previously loaded to the standard manhour setting system 2801 and then deleted on the standard manhour setting system 2801 side.

A field 4705b has a flag representing the approval state of a work standard. When the value is "F", it represents that the approver of the work standard is registered.

A field 4706 represents a number assigned to the work standard by the work standard creation system 2800. A field

4707 represents a number given to the work standard by the standard manhour setting system 2801.

Data is loaded in units of components. When the user selects the "execute" menu in Fig. 47, a "data load" window 4800 shown in Fig. 48 is displayed. The user designates the component symbol of a load target through a dialog 4801 in the window 4800.

More specifically, to load the component symbols of all components displayed, the user checks the "all" button. To designate and load a specific component symbol, the user checks the "designate component" button and inputs the component symbol name to a field 4802. As described above, for one component, a work name selected in the field 4701 in Fig. 47 with the mouse is recognized as one "component".

As shown in Fig. 49, in the standard manhour setting system 2801, a plurality of components can be defined. A single work can belong to different "components".

The advantage of providing "components" on the upper side of works is as follows. Since individual works themselves have high universality, they can hardly be strongly connected to a specific product. However, to re-define works in setting the manhour, or to re-define works in composing works in the workshop in consideration of the manhour, it is preferable for the user to connect the works to a name easy to remember the product to be manufactured, i.e., the name of the upper level.

Referring back to Fig. 48, the window 4800 also has a dialog 4803 in which a material to be referred to in automatically setting the manhour. That is, after the data load, whether an operation of automatically setting the manhour for the loaded work should be performed can be designated by a "standard material (CS) check button 4804 and "analysis material" check button 4805. The "standard material (CS)" is the standard material data file 2804, and automatic manhour setting by checking the "standard material (CS)" is manhour data setting by the above-described first route.

The "analysis material" is the operation pattern data file 2806, and automatic manhour setting by checking the "analysis material" is manhour data setting by the above-described second route. If the user does not want automatic manhour setting, both of the "standard material (CS)" and "analysis material" check buttons are turned off.

When the user clicks on an OK button 4806, the data load is started.

Fig. 50 shows the file structure of the standard manhour setting system 2801. As described above in relation to Fig. 36, the standard manhour setting system 2801 creates the manhour setting file 3601 on the basis of files loaded from the standard material data file 2804 and operation pattern data file 2806.

Referring to Fig. 50, the standard material data file

2804 and analysis material "operation pattern" data file 2806 are created by a standard material creation routine 5001 and analysis material creation routine 5002, respectively, in advance.

In the above way, more specifically, in accordance with the control procedure shown in Fig. 40 (this control procedure is included in a standard material manhour processing routine 5003), manhour data is automatically set for work data downloaded from the work standard creation system 2800.

As shown in Fig. 49, the respective "works" (the "works" are not the sets of a plurality of detailed works but simple root directories) required to assembly a product are linked by directories through one or a plurality of components (the components may be divided into a plurality of layers). In other words, when the directories are traced, the "product" assembly work can finally reach a work, and which manhour data is set for the work can be confirmed.

The program procedure of displaying work contents for this confirmation is included in the standard material manhour processing routine 5003. The manhour data automatically set by the standard material creation routine 5001 or analysis material creation routine 5002 can also be confirmed by the standard material manhour processing routine 5003. The standard material manhour processing routine 5003 will be described.

<Standard Manhour Processing>... Standard Manhour Setting System

Standard manhour processing is executed by clicking the "standard manhour processing" icon 4502 (Fig. 45). Individual "element works" correspond to work data and have a structure as shown in Fig. 38, as described above.

The standard material manhour processing routine 5003 is executed in accordance with the control procedure of the flow chart shown in Fig. 51. For the control procedure shown in Fig. 51, the directories are linked using a hierarchical structure

Product → component → model → work

In step S600, the "product" as a manhour setting target is selected. Fig. 52 shows the product selection window. The target "product" is selected with the mouse or the like, and a "set manhour" button 5201 is clicked. When this button is clicked, the flow advances to step S602 to select a "component". Fig. 53 shows the "component" selection window. A target component is selected with the mouse or the like, and a "next" button 5301 is clicked. When this button is clicked, the flow advances to step S604 to select a "model". Fig. 54 shows the "model" selection window. At this stage, in the example shown in Fig. 54, since the user has selected the "product" and "component", "BJ-970909" and "97-09-09 load" are displayed as a product symbol and product name, respectively. In addition, "CH" is displayed as a component

symbol.

Next, the target "model" is selected with the mouse or the like ("BJC-4300" is selected in the example shown in Fig. 54), and a "next" button 5401 is clicked. When this button is clicked, the flow advances to step S606 to select a "work" to be edited.

Fig. 55 shows the dialog for causing the user to select a "work" to be edited. At this stage, in the example shown in Fig. 55, since the user has selected the "product" and "component", "BJ-970909" and "97-09-09 load" are displayed as a product symbol and product name, respectively. In addition, since "CH" is displayed as a component symbol, and "BJC-4300" is selected as the "model", "BJC-4300" and "xxxxxxx" are displayed as a set model symbol and model name, respectively.

Referring to Fig. 55, a plurality of works are displayed. In a field 5501, the "formal management No" of each work is set. In a field 5502, the "name" of each work is set. In a field 5503, the manhour value set for each work is set.

A field 5504 ("USE" field) stores the directory (corresponding to "set condition field" in the example shown in Fig. 43) of manhour set on the basis of automatic manhour setting by the second route, i.e., the operation pattern data file 2806 (this file is created on the basis of works used in the past). A field 5505 ("CS" field) stores the root

directory (corresponding to "CS field" in the example shown in Fig. 42) of manhour set on the basis of automatic manhour setting by the first route, i.e., the standard material (CS) data file 2804.

At the stage in Fig. 55, the user can confirm manhour data (manhour value and manhour set condition (USE and CS)) automatically set. That is, in the manhour confirmation processes in step S4004 and S4014 of Fig. 40 are executed by the user through the display shown in Fig. 55. More specifically, in the example shown in Fig. 55, when a work has a value "0" as the "manhour" in the field 5503, it means that no corresponding work is registered in either the standard material data file 2804 or operation pattern data file 2806.

In step S4004, when the manhour in the window shown in Fig. 55 is "0", to automatically set the manhour by the second route, the user returns to the window shown in Fig. 48 to turn on the check box 4805 and click the OK button 4806.

After the end of automatic manhour setting by the second route, the window shown in Fig. 55 is displayed again, and it is confirmed whether a work having a "manhour" value "0" is present. If a work having a manhour value "0" is present, processing from step S608 in Fig. 51 is executed. Operations in step S608 and S610 correspond to step S4020 and S4022 in Fig. 40 (third route).

Step S608 in Fig. 51 is executed when the user clicks

a "change" button 5506 to change the contents of the elements (comments, object, and verb) of a work or set the manhour value.

Fig. 56 shows a user interface window for editing a work element. To change a work element, the comment 1, object, comment 1, and verb are corrected in fields 5601 to 5605. To reflect the correction to the setting file 3601, the button 5605 is clicked. To edit the next work element, a button 5606 is clicked.

To edit element works in units of genres, a user interface window shown in Fig. 57 is displayed.

<Operation Analysis>

As described above, when the manhour can be determined neither by the first route nor by the second route, the contents of each work are analyzed to determine the manhour using the third route. The control procedure shown in the flow chart of Fig. 51 is used for operation analysis in the third route.

To analyze a unit work, the user double-clicks on the name of a work to be analyzed in the window shown in Fig. 56. Then, step S610 is executed, and a user interface window shown in Fig. 58 is displayed.

In the user interface window shown in Fig. 58, the user inputs a target operation content to a field 5801 and a WF (Work Factor symbol) to a field 5802. A field 5803 stores the directory of a set condition.

In the example shown in Fig. 58, the operation of a work

"set main body to predetermined position"

is analyzed, and the manhour is calculated. The analysis contents and set conditions obtained by analysis are stored in the set condition field 5803 as a directory including the data.

More specifically, for the analysis operation, a WF must be set for a work "set main body to a predetermined position". To do this, the field 5802 is double-clicked.

The WF is a known Work Factor symbol. In the standard manhour setting system 2801 of this embodiment, a characteristic user interface window as shown in Fig. 59 is prepared to input the WF. In this embodiment, 17 WFs are prepared, as shown in Fig. 59. Since the user understands the operation content "set main body to predetermined position", he/she knows that this operation corresponds to "pickup" (WF = PU). Hence, the user would check a first button (PU) 5901 and click a "select" button 5902.

In accordance with selection of a button corresponding to a WF in Fig. 59, a user interface window shown in Fig. 60 or 61 is displayed. Of the 17 WFs shown in Fig. 59,

PU, GET, ASY, MA, DSY, R, and Ri

are WFs to be classified into a "table" type and can be set in the user interface window as shown in Fig. 60. In addition,

UMAC, MP, BODY, SUSD, TURN, STEP, and UMAN

are WFs to be classified into a "formula" type and can be analyzed in the user interface window as shown in Fig. 61. Furthermore,

M, TD, and WALK

are WFs to be classified into a "table/formula" type and can be analyzed in the above-described user interface windows as shown in Figs. 60 and 61.

The analysis setting user interface window for a table-type WF will be described with reference to Fig. 60 while exemplifying "pickup" (= PU).

Each operation is analyzed by a condition related to the operation and a threshold value used to determine whether the condition is satisfied. For the "pickup" operation of the example shown in Fig. 60, five (six at maximum in accordance with the display window size) conditions, "moving distance", "grip type", "pre-positioning", "main size", and "weight", are preset.

Six threshold values can be set for condition determination in accordance with the limited display window. In the example shown in Fig. 60, threshold values "-10 cm", "+10 cm", and ">5 cm" are prepared for "moving distance". Condition values are also preset for the remaining conditions, i.e., "grip type", "pre-positioning", "main size", and "weight". These condition and condition values (threshold values) are displayed when a "default value" button is

clicked. For each condition, the user selects a condition value that is suggested to be most appropriate. In the example shown in Fig. 60, the user selects

"+10 cm" for "moving distance",

"Qr-3" for "grip type",

"NO" for "pre-positioning",

"-10 mm" for "main size", and

"<3 kg" for "weight"

On the basis of the selection, the user would click on a "select" button 6001.

For the operation "set main body to predetermined position", which is to be analyzed by the user, since the user himself/herself selects "PU", the system side knows that the WF is of the table type, and analysis by a formula is unnecessary. Hence, to indicate that the user cannot operate, the icon of a "formula" button 6003 is displayed in a light color.

When the user clicks on the "set" button 6001, the system calculates the manhour (time) for each condition. For example, for the condition value "+10 cm" for the condition "moving distance", the moving speed of the worker is known, and time t1 required for movement by 10 cm is set for the condition "moving distance". In a similar way, for the remaining conditions "grip type", "pre-positioning", "main size", and "weight" as well, manhour times t2, t3, t4, and t5 are calculated, respectively, and the sum of times t1 to

t5 is stored in a field 5804 as a manhour. In addition, a directory for storing the conditions and contents of condition values set in Fig. 60 is stored and displayed in the set condition field 5802 shown in Fig. 58.

Fig. 61 shows analysis definition for a formula-type WF using an example "TURN" ("change direction of body). More specifically, when time (i.e., unit time) necessary for one cycle of the operation "change direction of body" is "10", a manhour for the operation "change direction of body" is generally represented by

10*m

where m is a variable representing the "number of times of operation of changing direction". In this system, a manhour formula "10*m" is set for TURN ("change direction of body") as a default value. Hence, referring to Fig. 61, the formula "10*m" is displayed in a field 6101, the variable name "the number of times of operation of changing direction" is displayed in a field 6102, and the unit of the variable, "times", is displayed in a field 6104. The user inputs the value of "times m" in a field 6103.

On the basis of the selection, when the user clicks on a "set" button 6105, the manhour value is calculated, displayed in the manhour field 5804 in Fig. 58, and stored in the memory.

The work procedures of work analysis and manhour determination according to the third route have been

described above.

<Log of Change in Manhour>... Standard Manhour Setting System

Starting from the dialog shown in Fig. 55, when the manhour set condition is changed, and the "change" button 5506 is clicked, the manhour value may change. The standard manhour setting system 2801 monitors whether the manhour value changes using click on the "change" button 5508 as a trigger.

When a change in manhour is detected, a user interface window shown in Fig. 62 is displayed to allow the user to input the change reason for the manhour. In the example shown in Fig. 62, a field 6201 contains "10" and indicates that the manhour change amount is "10". A field 6202 has a USE value "0" and indicates that the work data is still unused. The change reason for the manhour is input to a field 6204. In the example shown in Fig. 62, the change reason is "new setting" because a work is newly registered.

The reason code in a field 6203 is provided in a one-to-one correspondence with the change reason. When a new change reason occurs for a work, a reason code with an arbitrary code can be assigned to the change reason. However, to ensure integrity in the entire system, the reason code to be set is preferably determined in advance.

To display reasons for change in previous setting in the field 6204 in scroll, the user clicks on a button 6206.

The change reason code set in the user interface window

shown in Fig. 62 is displayed together with various kinds of information set for the work. For example, in the display window shown in Fig. 55, the reason code is displayed in a "correction" field 5507 (value "1").

This standard manhour setting system 2801 can hold the log of five changes (five or more if the memory allows) for one work. To confirm the log of change reasons, the column of the "correction" field 5507 of the work is double-clicked. Upon clicking, a change log correction window shown in Fig. 63 is displayed. The change reason is displayed in a field 6301, and preceding and succeeding manhour values are displayed in a field 6302. In the example shown in Fig. 63, the work "electrical check" has only one change reason. However, when a plurality of change reasons are present, five change reasons are displayed at maximum while being stacked on the lower side.

<Work Assignment System>

As shown in Fig. 28, the work standard creation system 2800 creates work standard data containing no manhour data, and the standard manhour setting system 2801 creates the manhour setting file 3601 from the work standard data.

As shown in Fig. 64, the work assignment system 2802 downloads (loads data) the contents of the manhour setting file 3601 and creates a composition table file 6400. The work assignment system 2802 also determines the range of composition in the loaded manhour setting data, composes

works within that range in accordance with a predetermined purpose, corrects the composition, and outputs the composition. In other words, it may safely be said that the work standard creation system 2800 and standard manhour setting system 2801 exist such that the work assignment system 2802 can

· automatically execute composition,
· allow the user to easily grasp the composition result,
· easily correct the composition contents, and
· do composition matching the set purpose.

Fig. 65 illustrates inputs to the work assignment system 2802 and outputs from the work assignment system 2802.

Referring to Fig. 65, the work assignment system 2802 receives the range to be composed as range data 6502. Work data downloaded in accordance with this range is used for the composing operation. Also, division condition data 6503 for division to stations is input as a condition for composition.

Composition here means that a plurality of works in an order defined by the work standard creation system 2800 are distributed to a plurality of "stations" in accordance with the order of works (including a case wherein the order is changed by the work assignment system 2802).

A station means a physical station or simply indicates a plurality of work groups put together in terms of concept. Each station is assigned a specific operator. In this

assignment, the work assignment system 2802 assigns a specific operator on the basis of the information of each operator (experience time or the degree of skill for a work), which is stored in an operator database 6501.

The work assignment system 2802 outputs a simple division window display output 6504 or window display output 6505 (considering the parallel operation of works) to the display unit such that the user can easily confirm the composition result. The composition data can also be output in the EXCEL format as an example of a general document data format.

The work assignment system 2802 provides two division methods as composition methods. As one method, works are simply divided to stations. As the other method, works are divided to stations in consideration of the parallel operation of the works (to be referred to as "parallel division" hereinafter for the descriptive convenience). For either division method, work data download from the standard manhour setting system 2801 to the work assignment system 2802 is necessary.

Fig. 67 shows an example in which some works related to the assembly work of a model "GP55" are loaded to the work assignment system 2802 and displayed on the screen of the display unit. Referring to Fig. 67, "standard No" represents the work order defined by the work standard creation system 2800 and edited or corrected by the standard

manhour setting system 2801. In other words, the work assignment system 2802 initially recognizes the order of work data in the manhour setting file 3601 of the standard manhour setting system 2801 as the work order in the work assignment system 2802. For data in the range of the loaded data (or the range designated by the work assignment system 2802), simple division or parallel division is executed.

In the example shown in Fig. 67, the assembly work of one unit of model "GP55" comprises seven (or more) works

· NO. 1: stick handy cut tape
· NO. 2: set labels on main body
· NO. 3: Weiman removal
· NO. 4: assemble outer case
· NO. 5: fit top pad
· NO. 6: stick large-side order label

The manhour of these works is

$$134 + 550 + 270 + 365 + 268 + 117 = 1704 \text{ RU}$$

In this case, 1 RU is 1/1000 min.

<Simple Division>... Work Assignment System

Generally, letting WF (unit: RU) be the total manhour in the composition, U be the number of units (the number of products) to be produced by one crew as a set of a plurality of operators per day, H (unit: RU) be the operation time of one crew (a set of a plurality of operators) per day, and E be the target composition efficiency (i.e., expected composition efficiency), the number of stations N_S to be

divided is given by

$$N_{ST} = (U \times WF)/(H \times E) \qquad \ldots (1)$$

That is, when N_{ST} stations are prepared, the above object can be achieved. In this setting, the time (i.e., pitch time T_P) required for work in each station is given by

$$T_P = H/U \qquad \ldots (2)$$

In other words, the total manhour of works assigned to one station by simple division is assigned such that it almost matches the pitch time T_P in average. In the example shown in Fig. 66,

$$t1, t2, \ldots, tn-1, tn \fallingdotseq T_P \qquad \ldots (3)$$

Fig. 68 shows a display window in which the works shown in Fig. 67 are divided to plurality of stations, and the work contents of station 1 (St1) and station 2 (St2) are displayed. More specifically, of the seven or more works shown in Fig. 67, works Nos. 1 to 3 are assigned to station 1 (St1) and works Nos. 4 to 6 are assigned to station 2 (St2). In the example shown in Fig. 68, the total manhour in station 1 (St1) is 954 RU, and that in station 2 (St2) is 750 RU. The total manhours "945 RU" and "750 RU" should fall within the pitch time T_P.

However, in an actual production workshop, composition based on the theory may lower the efficiency. As a measure against this, the work assignment system 2802 prepares a means for easily correcting/changing the contents of composition. The correction/change means is shown in

Fig. 69.

Fig. 69 shows a user interface window as the correction/change means displayed on the display screen of the display unit of the work assignment system 2802. More specifically, a bar graph 6901 represents the manhours (RU) assigned to the stations as a result of simple division. Reference numerals 6902 and 6903 denote contents of works assigned to the respective stations, which correspond to the graph 6901.

Referring to Fig. 69, the bar representing the manhour of the station St1 matches the pitch time T_p, the bars for the stations St2 and St3 are shorter than the pitch time T_p, and the bar for a station St4 exceeds the pitch time T_p.

A certain user may average the variation in manhour between the stations by exchanging the works between the stations. In addition, a certain user may empirically know that the efficiency can be improved by moving a specific work to another station although it increases the variation in manhour.

To cope with this, in the work assignment system 2802, a work in the station St1 and a work in the station St2 shown in the table 6902 can be exchanged. When exchange is actually done, the variation result of the total manhour in each station in accordance with the exchange is reflected to the bar graph 6901. In other words, the process change result can be visually confirmed on the bar graph.

For correction or editing in the work assignment system 2802, not only exchange of two works between different stations but also a change in work order in a single station, integration editing for integrating two works to one work, and editing for dividing one work into two works are prepared.

<Parallel Division>... Work Assignment System

In the simple division, works are divided to a plurality of stations simply in accordance with the work order defined by the work standard creation system 2800 or standard manhour setting system 2801. This simple division does not consider that there are some works that can be operated in parallel. Parallel division is division that takes the parallel operation of works into consideration.

Fig. 70 shows a user interface window for defining the parallel operability of works. For the descriptive convenience, the example shown in Fig. 70 assumes an assembly procedure for a total of 14 works with numbers S (start) to 13. Assume that the names, process number, and manhours of all works as shown in Fig. 67 are displayed on the display screen of the display unit for user confirmation.

The user defines the parallel operation of works, which is known based on the experience of himself/herself, using work icons and link lines for connecting the work icons, as shown in Fig. 70, while confirming the order of works on the table as shown in Fig. 67. In the example shown in Fig. 70, a work icon is symbolized by a circle and a work number in

the circle.

In the example shown in Fig. 70, for example, since works 1, 11, and 3 are linked to work S and have no priority therebetween. Since work 4 linked to start work S must be executed subsequently after work 3 linked to start work S, work 4 cannot be handled equivalently to works 1, 3, and 11.

Even when the order of works 1, 3, and 11 which are parallel to each other and have no priority therebetween is changed, no problem is posed. This means that when parallel operation is taken into consideration, a plurality of composition plans are available. The work assignment system 2802 proposes composition plan 1, composition plan 2,... and displays them, as shown in Fig. 71.

In this system, to present a plurality of composition plans, a parallel work "group" designation function as shown in Figs. 92 and 93 is set.

Group designation of works means that the same group code is given to a plurality of works to assign them to a single station. The group designation function is provided to designate works requiring the same tools to the same group or works using components on a single attachment surface to the same group to suppress the purchase cost for expensive tools, or designate works to the same group in order to put assembly works together to effectively use the machine manhour time for other works such that works having the same group code are prevented from being assigned to different

stations.

Conventionally, the priority of assignment based on such a condition is processed by logic (rule or the like). However, since designating works using the same tools to the same group may be inconsistent to designating works using components on a single attachment surface to the same group, unique determination may result in an assignment error. In this system, a person experienced in work assignment can manually give a group code to works to be assigned to a single station before execution of automatic composition.

However, group designation that impedes assignment based on the priority table is not allowed, as shown in Fig. 94.

As shown in Fig. 92, when works 2 and 3 are designated to a group, works 2 and 3 are assigned to a single station (composition plan 1 in Fig. 71).

On the other hand, as shown in Fig. 93, when works 2 and 8 are designated to a group, works 2 and 8 are assigned to a single station (composition plan 2 in Fig. 71).

As shown in Fig. 94, group 1 cannot be designated because work 8 outside the group is inserted between works 2 and 12. This is because work 8 must be executed after work 2 and before work 12 and cannot be executed when work 8 is assigned to a station different from that for works 2 and 12. To designate works 2 and 12 to the same group, work 8 inserted therebetween must also be designated to the same

group.

As a result of such composition, according to composition plan 1, works Nos. 1, 2, and 3 are assigned to station 1 (St1), and works Nos. 4, 5, and 6 are assigned to station 2 (St2). On the other hand, according to composition plan 2, works Nos. 1, 2, and 8 are assigned to station 1 (St1), and works Nos. 3, 4, and 5 are assigned to station 2 (St2).

A user interface as a composition editing means as in simple composition as shown in Fig. 72 is prepared for each of the composition plans composed by parallel division. Fig. 72 shows a user interface for composition plan 1, and Fig. 73 shows a user interface for composition plan 2.

<Details of Control Procedure>... Work Assignment System

The work assignment system 2802 prepares two load sources of work data to be composed, i.e., the manhour setting file 3601 (standard manhour setting system 2801 side) and the composition table file 6400 (work assignment system 2802 side), as shown in Fig. 64. More specifically, when the work assignment system 2802 is activated, and the "load new file (N)" menu of the file menu is selected, data can be loaded from the manhour setting file 3601. When the "open (O)" menu of the file menu is selected, a target work file can be opened from the composition table file 6400.

Fig. 74 shows a user interface window for a data load when the "open new file (N)" menu is selected.

In this work assignment system 2802 as well, a set of

work data linked by directories having a hierarchical relationship

genre → representative model → target model → composition

is defined, as in the work standard creation system 2800 and standard manhour setting system 2801. In other words, the set of work data linked to each other by the above hierarchical relationship defined by the work standard creation system 2800 is succeeded by the manhour setting file 3601 of the standard manhour setting system 2801 while holding the hierarchical relationship.

The hierarchical relationship and contents of work data succeeded by the manhour setting file 3601 are edited or worked by the standard manhour setting system 2801. Work data as the result must also be succeeded by the work assignment system 2802 from the standard manhour setting system 2801. For this purpose, the work assignment system 2802 has a user interface capable of designating one or more or all of the four layers as data load targets from the standard manhour setting system 2801.

As such a user interface, for example, to load data from the manhour setting file 3601 in units of genres, the name of the genre is input to a field 7401, as in the example shown in Fig. 74. In a field 7402, a set of all work data at the "genre" level present in the field 6301 of the standard manhour setting system 2801 is displayed.

In the example shown in Fig. 74, bubble-jet printer (BJ), facsimile apparatus (FAX), laser beam printer (LBP), and the like are displayed as genres. When one genre is selected in the field 7401, and an "OK" button 7408 is clicked, a set of all work data belonging to the genre is downloaded from the manhour setting file 3601.

If the user wants download in units of "representative models", the name of a genre to which the representative model belongs is input to the field 7401. Then, the names of all representative models belonging to the selected genre are displayed in a field 7404. When, of these displayed names, the name of a desired "representative model" is double-clicked, the name is copied to a field 7403, and then, the "OK" button 7408 is clicked.

If the user wants download at the "target model" level, the name of the target model is input to a field 7405, or a field 7406 is selected, and then, the "OK" button 7408 is clicked.

The work assignment system 2802 has a user interface capable of setting to download a plurality of "components" at the "component" level at once. In a field 7407 shown in Fig. 74, the names of all components belonging to a "target model" of a "representative model" in a "genre" are displayed, so a plurality of "components" can be selected while designating the download order thereof. To designate the download order, sequential numbers are input to an order

column 7409 of the "components" selected by clicking of the mouse.

The user interface shown in Fig. 74 and, more particularly, arbitrary setting at the component level has the following advantage.

For example, assume that work data of a model named "X" is stored in the manhour setting file 3601, and components "A", "B", "C", "D", "E",... belong to the model "X", as shown in Fig. 75. When the user interface shown in Fig. 74 is used,

model "X1" (including the components "A", "B", and "C"),

model "X2" (including the components "A", "B", and "D"),

model "X3" (including the components "B", "C", and "A"),...

can be downloaded from the model "X", as shown in Fig. 75. When these new models "X1", "X2", and "X3" are downloaded, they are registered in the work assignment system 2802 as new directories. The reason for this is as follows. Since the work composing operation is close to the site of assembly, it is preferable to allow the user to determine work composition with components more appropriate to the site of assembly and also, even for the same model, define work composition whose components are easily changed.

To create a plurality of different "model" directories from one "model" directory, the work assignment system 2802

adds "?n" (n is a number) to the directory name of the original "model".

Fig. 76 shows a user interface window for opening an existing file in the composition table file 6400. In the work assignment system 2802, to open an existing file, files are selected in units of "target models". The "target model" includes the "target model" defined in the field 7405 in Fig. 74 and the "target models" newly automatically defined in Fig. 75.

The user clicks on one of a plurality of "target models" displayed in the field 7601 using the mouse or inputs the name of a desired "target model" to a field 7602. The "revision number " of the selected "target model" is displayed in a field 7604. Whether the composition data input window or composition data editing window for the selected "target model" is to be displayed is selected by check buttons 7605.

Referring to Fig. 77, work data loaded to the memory of the work assignment system 2802 by the above-described download or file open operation are displayed in units of "target models".

More specifically, the work data are displayed as a list in a field 7706. The name of the target model is displayed in a field 7701, the file name is displayed in a field 7702, and the revision number is displayed in a field 7703. A "total work count" N_T for the "target model" is

displayed in a field 7707, and the total manhour is displayed in a field 7708.

The number or name of a work selected in the field 7706 with the mouse is displayed in a field 7705. The total manhour in composition is displayed in a field 7709.

An input for defining conditions for composition is done in a window 7710. Bibliographic data of the composition result are displayed in a window 7720.

Data related to the above-described equation (1) are input to the input window 7710. More specifically, the user inputs the number of units (the number of products) U to be produced by one crew as a set of a plurality of operators per day to a field 7710a, time (i.e., operation time of each station) H (unit: RU) obtained by subtracting an exclusive time such as a break from one-day working time of one crew (a set of a plurality of operators) to a field 7710b, and the target composition efficiency (i.e., expected composition efficiency) E to a field 7710c. As the total manhour in the composition, which is represented by equation (1), the total manhour (field 7709) not input by the user but calculated by the system is used, as described above.

When "calculate" button 7710d is clicked, the number of stations N_{ST} is calculated in accordance with equation (1), and the pitch time T_t is calculated in accordance with equation (2) on the basis of the conditions input to the window 7710.

The number of stations N_{ST} is automatically calculated

in accordance with $N_{ST} = (U \times WF)/(H \times E)$ (equation (2)) and displayed in a field 7720a when the value is rounded down or in a field 7720b when the value is rounded up, together with the composition efficiency. That is, when the number of stations N_{ST} is rounded down, the composition efficiency becomes higher than the target composition efficiency (field 7710c), and when the number of stations N_{ST} is rounded up, the composition efficiency becomes lower than the target composition efficiency.

The pitch time T_P is displayed in a field 7720d.

The user can edit the composition in units of works while looking at the window shown in Fig. 77. The editing commands are "divide", "integrate", "insert before", "insert after", "delete", "change work order", "in composition", and "outside composition". These editing menus are done from the editing menu provided by the window system or by selecting a desired work with the mouse and clicking the right button of the mouse.

To "divide" a work means that one unit work is divided into two unit works. The manhour value of each divided unit work is "0". The number of each divided element work has a subnumber. The name of each divided element work has an indent.

To "integrate" works means that two element works are integrated to one unit work. The manhour of the integrated unit work corresponds to the sum of manhours of the respective

element works as integration targets.

With the "insert before" menu for a work, a work designated by the dialog shown in Fig. 78 is inserted before a selected work. More specifically, the name of work to be inserted is written in a field 7801, and a temporary manhour value is written to a field 7802.

The "insert after" menu for a work is almost the same as the above "insert before" menu.

With the "change work order" menu, the positions of two works are exchanged.

With the "in composition" or "outside composition", it is determined whether a work is to be subjected to composition or excluded from the composition targets.

The operation of composing all works of the "target model" is started by clicking on an "execute composition" start button 7730.

Fig. 79 is a flow chart for explaining the control procedure of composition. In step S790, counters i, j, and k for work are initialized to "1", and a register T for storing the accumulation time of manhours for each station is initialized to "0".

In step S791, data of a work wj (manhour tj) indicated by the counter j is extracted. In step S792, the manhour tj is accumulated to the time register T. In step S793, the counter j is incremented by one. In step S794, it is determined whether the manhour value accumulated in the time

register T exceeds the pitch time T_P. If NO in step S794, the flow returns to step S791 to repeat the above-described operation.

That the accumulated manhour value T of manhours tk to tj exceeds the pitch time T_P means that works wk to wj should belong to a station Sti, so the works wk to wj are assigned to the station Sti. In step S796, the counter i is incremented to prepare for setting the next station. In step S797, the counter k is returned to "j", and the time register T is initialized to "0".

In step S798, it is determined whether the counter value j representing the work number exceeds the total number of works N_{WA}. If YES in step S798, the processing is ended.

The control procedure shown in Fig. 79 determines assignment of works to stations with priority on the manhour. That is, assignment is determined that the accumulated manhour value T preferentially should not exceed the pitch time T_P. The number of assigned stations may eventually be larger than the number of stations N_{ST} set as a target, and if so, the composition efficiency changes accordingly.

For work assignment, a determination method with priority on the number of stations (Fig. 95) or an assignment determination method based on the accumulated manhour value (Fig. 96) can be proposed as a modification.

The assignment method shown in the flow chart of Fig. 95 gives priority on that the total number of stations

to be assigned works should not exceed the upper limit value N_{ST}. For this purpose, variables, a parallel number ni and total accumulated parallel sum number n0, are newly introduced, unlike the control shown in Fig. 79. The parallel number ni is the number of stations that can be parallel-operated in the stations i.

In step S950, the counters i, j, and k for work are initialized to "1", the register T for storing the accumulated time of manhours for each station is initialized to "0", and the total accumulated parallel sum number n0 is initialized to "0". In step S951, data of the work wj (manhour tj) indicated by the counter j is extracted. In step S952, the manhour tj is accumulated to the time register T.

That is, the accumulated manhour value of the manhours tk to tj is stored in the time register T. In step S953, the counter j is incremented by one. In step S954, it is determined whether the manhour value for the station i exceeds the pitch time T_P. Since the station i is allowed to parallel-operate ni stations in advance, and the manhour that can be assigned to the station i is $T_c \times ni$, more works can be assigned to the station i when

$$T < T_c \times ni \qquad \ldots (4)$$

When

$$T \geqq T \times ni \qquad \ldots (5)$$

no more works can be assigned to the station i. In step S954, such determination is done. In step S955,

$$i + n0 < N_{ST} \quad \ldots (6)$$

is determined to confirm that the total number of stations assigned works does not exceed the upper limit value N_{ST}. More specifically, when equation (5) holds for a certain station i (the assigned manhour T exceeds the pitch manhour ($T_P \times ni$) considering parallel operation), the station Sti is newly set in step S956 unless the total number of stations (i + n0) set so far exceeds the upper limit value N_{ST}.

The purpose of step S955 is to prevent the number of assigned station from exceeding N_{ST} by assigning works beyond the pitch manhour T_P to the final station.

If YES in step S955, the counter i is incremented in step S957 to prepare for setting the next station, and the register n0 is updated in accordance with

$$n0 = n0 + (ni - 1) \quad \ldots (7)$$

where ni in (ni - 1) is the parallel number defined in advance for incremented i, i.e., the station i to be taken into consideration next. Hence, n0 in equation (7) is the accumulated value of parallel numbers set for the first to (i-1)th stations. In step S958, the counter k is set to "j", and the time register T is initialized to "0".

In step S959, it is determined whether the counter value j representing the work number exceeds the total number of works N_{SA}. If YES in step S959, the processing is ended.

As described above, in the control procedure shown in Fig. 95, to prevent the number d of assigned stations St from

exceeding the number of stations N_{ST} set as a target, all works remaining at the time of end of assignment to the station (i - 1) are assigned to the final station (i.e., station i). With this method, the number of assigned stations is prevented from exceeding N_{ST} by assigning works beyond the pitch manhour T_P to the final station.

However, in the method shown in Fig. 95, the load (manhour) may be concentrated to the final station. To prevent this, the assignment method shown in the flow chart of Fig. 96 has as its object to keep the number of stations N_{ST} set as a target and distribute the load (manhour) without concentrating the load to the final station such that the variation in manhour between the stations is easily evened. To do this, unlike the control shown in Fig. 95, let Ti be the manhour to be assigned to the station i, and T0 be the accumulated manhour assigned to all stations assigned works. Additionally, a new variable, station manhour T_S is introduced.

The station manhour average value T_S is defined by

$$T_S = WF/N_{ST} \qquad \ldots (8)$$

When equations (1) and (2) are taken into consideration.

$$T_S = E \times T_P \qquad \ldots (9)$$

In the control procedures shown in Figs. 79 and 95, the pitch time T_P defined by equations (1) and (2) is used as a reference for determination whether the station Sti is to be set. However, the control procedure shown in Fig. 96,

the station manhour average value T_i defined by equation (8) is used as data for determination whether the station Sti is to be set.

In step S960 of Fig. 96, the counters i, j, and k for work are initialized to "1", the register T for storing the accumulated time of manhours for the station i is initialized to "0", the total accumulated manhour T0 is initialized to "0", and the total accumulated parallel sum number n0 is initialized to "0". In step S961, data of the work wj (manhour tj) indicated by the counter j is extracted.

In step S962, the manhour tj is accumulated to the time register T. That is, the accumulated manhour value of the manhours tk to tj for the station i is stored in the time register T. In step S963, the manhour tj is accumulated to the time register T0 to update the total accumulated manhour T0. In step S964, the counter j is incremented by one. In step S964, it is determined whether

$$T0 > T_i \times (i + n0) \qquad \ldots (10)$$

As described above, (i + n0) is the total number of stations assigned works so far in determining whether the ith station is to be set. For this reason, when equation (10) holds, all works corresponding to the accumulated manhour Ti can be assigned to the station Sti in step S965.

In the method shown in Fig. 95, assignment is determined on the basis of the pitch time T_i that is uniform to all stations. However, in the method shown in Fig. 96,

the accumulated value based on the manhour average value T_i is used as a reference. Hence, works are prevented from being excessively assigned to a specific station.

Fig. 80 shows an example in which the composition created by the control procedure shown in Fig. 79 is displayed. As characteristic features of the work assignment system 2802, composition can be easily corrected, as described in association with Fig. 69, and also, correction can be done while confirming the correction process in real time. Referring to Fig. 80, the work assignment states of five out of the total of N_{st} stations are displayed.

The number of stations for display is limited to five due to a limitation on the screen size of the display unit. The total manhour value of each station is stored and displayed in a field 8004.

The total manhour of each station is displayed in a bar graph (8006). The composition efficiency is displayed in a field 8007.

Reference numeral 8008 denotes a display window of works outside the composition; and 8009, a display example of a menu displayed by clicking the right button of the mouse. The work outside the composition and the works listed for the station can be exchanged.

The editing commands "divide", "integrate", "insert before", "insert after", "delete", "change work order", "in

composition", and "outside composition" are allowed for works displayed in the composition target definition window shown in Fig. 77. As in this window, editing commands "divide", "integrate", "insert before", "insert after", "delete", "change work order", "in composition", and "outside composition" are also prepared for the works listed for the five stations displayed on the window shown in Fig. 80. In the compositor data correction window, the "change work order" menu is displayed as a "move" menu.

The function of "dividing" a work in the composition result will be described first.

This function is necessary when the user looks at the graph in Fig. 80, finds that the manhour of a specific station is particularly larger than that of the remaining stations, and wants to divide the specific work. In this case, one of the divided subworks is left to the station, and the other subwork is moved to another station. "Divide" and "move" in this example will be described with reference to Figs. 81 to 83.

Assume that a plan as shown in Fig. 81 is obtained by a composing operation. As is apparent from the example shown in Fig. 81, the total manhour of station 1 is larger than that of station 2 by 38 RU. The cause for this is the work "A4" assigned to station 1, as is known from the work table.

The user selects the work "A4" with the mouse, displays the menu by clicking the right button of the mouse, and selects

the "divide" menu (or double-clicks). The work "A4" is divided into works "A4-1" and "A4-2" each having a 1/2 manhour, as shown in Fig. 82. The user selects the "move" menu to move the work "A4-2" from station 1 to station 2. The result of movement is reflected to the graph, as shown in Fig. 83.

For the remaining functions, e.g., "integrate", "insert", and "delete" of a work as well, a desired work is selected with the mouse, and the menu is selected (for "integrate", the menu can also be double-clicked), thereby reflecting the editing result to the graph.

The editing function in the work assignment system 2802 includes not only editing in units of work but also editing in units of stations. The functions are "delete", "insert", "add", and "parallel integrate" of a station.

With "delete" of a station, a station which has become empty as a result of "move" of works is deleted. As a detailed user's operation, an empty station is selected in the window shown in Fig. 80. The right button of the mouse is clicked to display the "delete" menu of the station, and the menu is selected, thereby deleting the station. A station can also be added to add a work.

With "insert station ", an empty station is inserted between two stations. As a detailed user's operation, an arbitrary work in the station located on the front side is selected with the mouse. Next, the right button of the mouse is clicked to display the "insert station" menu, and the menu

is selected. With this operation, an empty station is inserted.

With "add station", a station is added next to the station as an addition target. As a detailed user's operation, an arbitrary work in the station as an addition target is selected with the mouse. Next, the right button of the mouse is clicked to display the "add station" menu, and the menu is selected. With this operation, an empty station is added. The newly created station is additionally displayed after the station as the addition target. Since the added station has no work, a work is moved from another station.

With "parallel-operate stations", to allow work by a plurality of operators, a work in a station is divided into stations equal in number to the plurality of operators. As a detailed user's operation, a desired station is selected with the mouse, the right button of the mouse is clicked to display the "parallel integrate" menu, and the menu is selected. Then, a dialog shown in Fig. 84 is displayed. The number of stations to be divided is written in a field 8402.

Fig. 85 shows an example of station division before parallel operation. In this example, the number of works assigned to the station St2 displayed as "operator 2" is large, and the time is also long. With the above parallel operation, station 2 is divided into stations St2-1 and St2-2, as shown in Fig. 97.

For the illustrative convenience, St1 expressed as "operator 1" in Fig. 85 corresponds to St1 expressed as "operator 1" in Fig. 97. However, St3 expressed as "operator 3" in Fig. 85 corresponds to St3 expressed as "operator 4" in Fig. 97. In addition, St4 expressed as "operator 4" in Fig. 85 corresponds to St4 expressed as "operator 5" in Fig. 97, and St5 expressed as "operator 5" in Fig. 85 corresponds to St5 expressed as "operator 6" in Fig. 97.

Addition of a station (or addition of a work) at the time of composition is effective when a station (or work) for check (inspection) is to be added. Whether the inspection process is necessary can hardly be determined by the work standard creation system 2800 for defining the work or the standard manhour setting system 2801 for defining the manhour. Such determination is necessary and possible when the work assignment system 2802 is operated. When a previous or subsequent station as an addition target is designated with the mouse, and the "add" station menu is selected, a newly created empty station is displayed after the addition target station.

<Modification to Composition>

The form of composition is not limited to the above examples.

For example, there may be a single work requiring a large manhour. Even when such a work is present, composition can be theoretically executed in accordance with equations

(1) and (2). However, the time for the single work having a large manhour exceeds the pitch time $T_{?}$. For example, one station is assigned to the single work, like station 2 shown by 8601 in Fig. 86.

The display shown on the upper side (8601) of Fig. 86 is not preferable because the window is inefficiently occupied. In the work assignment system 2802, letting n be a value obtained by dividing the total manhour in the station assigned such a single work having a large manhour by a number (to be referred to as a unit manhour hereinafter) obtained by multiplying the pitch time $T_{?}$ by a predetermined value (a constant can be used), and rounding up the quotient, n operators are assigned to the station. The graph display of the manhour of such a station has a width n times the normal bar width. The width of the station 2 bar in Fig. 86 is doubled (8602 in Fig. 86). With this display, the user can understand at a glance that the station has a single work with a large manhour, and its manhour represented by a multiple of the above "unit manhour".

Only a specific user can perform the composing operation. The user interface window shown in Fig. 87 is an input window for checking the operator has a right for composition. The operator code is input to a person name code column 8701, the name of the operator is input to a column 8702, the position is input to a column 8703, the password is input to a column 8704, and the authority is input to a

column 8705. The input data are collated with a personnel database, and only when the data match, an access right is given.

Fig. 88 shows the data upload from the work assignment system 2802 to the work standard creation system 2800 when the work standard creation system 2800, standard manhour setting system 2801, and work assignment system 2802 have standalone structures.

As described above, the work standard creation system 2800 of this embodiment can attach voice or image data to a work standard. In the above embodiment, the work standard creation system 2800, standard manhour setting system 2801, and work assignment system 2802 build a client/server database system, as shown in Fig. 1. For this reason, the download or upload by batch operation of work standard data is unnecessary between the work standard creation system 2800, standard manhour setting system 2801, and work assignment system 2802.

However, when work standard creation system 2800, standard manhour setting system 2801, and work assignment system 2802 have standalone structures, as shown in Fig. 88, the data download or upload between the subsystems is necessary. In this case, it is inefficient to download or upload image data or voice data created by the work standard creation system 2800.

In the modification shown in Fig. 88, download or

upload is limited to download or upload of minimum necessary data. Merging between image data or voice data and work standard data composed by the work assignment system 2802 is executed by the work standard creation system 2800. This shortens the time required for the download or upload.

In addition, the work standard creation system 2800 can be connected to each station in the workshop through a LAN (communication network), so work standard data, including image data or voice data, can be downloaded to the workstation of each station through the LAN.

<Other Modifications>

M-1: The above-described embodiment is constructed under the client/server environment, as shown in Fig. 1. However, the present invention can also be applied to a standalone environment in a single computer system. In this case, the work standard creation system 2800, standard manhour setting system 2801, and work assignment system 2802 operate in the computer system.

M-2: In the above-described embodiment, various files are created in each system, and the formats of these files can be set in various ways. For example, these files need not always be so-called permanent files always stored in an external auxiliary storage device such as a disk and can be so-called view files which are present only on the main memory. This is because many files are temporarily created for the purpose of display (view).

[Second Embodiment]

To optimize the result of assignment of the individual works composed using the "assembly standard information management system" described in the first embodiment in accordance with the actual situation, in the production line to which the individual works are assigned in the above-described procedure, it must be taken into consideration to set the number of units with the number of defective products (the number of products that fall off from the line) to the production line immediately before actual production (mass production) or in accordance with various management data totalized for every predetermined period after the start of mass production or the situation of the target production period.

The number of defective products means the number of products that are omitted (fall off) from the production line midway during the production process due to some error factor.

The above-described assembly standard information management system will be examined from such a viewpoint. Assignment of individual works that are composed is a static arithmetic result under an assumed stable production situation, which does not take actually possible dynamic factors into consideration, including a variation in defective part inclusion ratio, the difference in the number of assembled products between stations, and the difference

or variation in performance between the stations. Hence, it is expected that the actual production line to which the individual works are assigned in accordance with the calculation result cannot be an optimum system in some cases.

In such a case, as the result of actual production, adjustment is expected to be done complying with the discretion of an experienced chief of the workshop who knows the contents of various works and the structure of the product well: a work is moved from a station as a bottleneck (to be referred to as a neck station hereinafter) to another station, or a work requiring a large manhour, which is included in the neck station, is exchanged with a work which is already assigned to another station and has a small manhour.

In addition, when it is determined by the above determination operation that the number of stations is too small, stations are expected to be appropriately added to achieve the planned number of products on the production line. Especially, when the number of stations is too small, and adjustment is done to increase the number of stations, not only the planned production quantity cannot be achieved but also the already built production line is reconstructed, resulting in large loss of hardware and work time.

Furthermore, when various works are assigned, as described above, the load balance between the stations of the production line is poor and is limited by the work time required by the neck station. In some cases, the production

quantity planned on the production line cannot be achieved.

Also, when the assignment operation is executed assuming a stable production situation, as described above, that the number of stations is too small may be recognized for the first time under a situation that the planned production quantity cannot be actually achieved. In this case, even when the operator wants to set predicted values in the assignment operation which is performed first, these values to be set are actually often available only immediately before production. Even when the predicted values are set on the basis of the experience and intuition in the assignment operation, they may largely deviate from the actually required production quantity at the time of production.

In addition to the characteristic feature of the aid system according to the first embodiment: "a work constituted by a plurality of work standards can be automatically and efficiently assigned to a plurality of stations and composed by a computer", the second embodiment also has as another object to "provide an aid system capable of easily adjusting a composition to that capable of producing the expected number of products in consideration of an actual variation factor".

The system to be described below in the second embodiment has a function of expanding the above-described "assembly standard information management system" of the

first embodiment shown in Figs. 98A and 98B.

More specifically, the assembly standard information management system comprises three subsystems:

· work standard creation subsystem 2800,

· standard manhour setting subsystem 2801, and

· work assignment subsystem 2802

However, as the overall arrangement of the system to be described in the second embodiment, as shown in Figs. 99A and 99B, a "production simulation system" and the assembly standard information management system shown in Figs. 98A and 98B are combined. In this embodiment, this combined system will be called a "simulation cooperating work assignment system".

The simulation cooperating work assignment system of this embodiment is constructed by a total of four subsystems, i.e.,

· production simulation system 2850

in addition to the above three subsystems.

In the following explanation, these subsystems will be referred to as the work standard creation system 2800, standard manhour setting system 2801, work assignment system 2802, and production simulation system 2850, as in the first embodiment. The functions of the four subsystems will be briefly described.

The work standard creation system 2800 creates (defines) a work standard (work standard data) for the

standard manhour setting subsystem 2801 and work assignment subsystem 2802, as described in the first embodiment (a detailed description thereof will be omitted).

The standard manhour setting system 2801 determines the standard manhour for the work standard created by the work standard creation system 2800, as described in the first embodiment (a detailed description thereof will be omitted).

The work assignment system 2802 assigns various works (creates a composition plan) using the work standard created by the work standard creation system 2800. The work assignment system 2802 of the second embodiment has almost the same function as that described in the first embodiment. The second embodiment is slightly different in the use method by the user and in that data exchange with the production simulation system 2850 is possible.

The production simulation system 2850 executes simulation using the composition created by the work assignment system 2802 and creates and outputs the simulation condition set at that time and the simulation result.

The work assignment system 2802 can re-determine (recalculate) the composition to be output using the simulation condition and result created by the production simulation system 2850.

More specifically, the user can repeatedly instruct the computer to execute a series of processes that the production simulation system 2850 executes simulation using

a composition created by the work assignment system 2802, and the work assignment system 2802 re-determines the composition using the simulation condition set at that time and the simulation result until a desired simulation result is obtained.

<Overall Arrangement>

As shown in Fig. 99B, the "simulation cooperating work assignment system" of this embodiment comprises a plurality of clients and one server (or a plurality of servers). The computer system of each client (to be referred to as a client system hereinafter) has, e.g.,

· OS: Windows95/98,

· DB connection software: ODBC driver for Oracle,

· communication network software: SQL-Net for Oracle,

· work standard creation system application program,

· standard manhour setting system application program,

· work assignment system application program, and

· production simulation system application program.

On the other hand, the server-side computer has a system configuration comprised of

· OS: Windows95/98, and

· database: Oracle WorkGroup Server

On the simulation cooperating work assignment system constructed by a plurality of clients and one or a plurality of servers, four application programs or the "work standard creation system 2800", "standard manhour setting system

2801", "work assignment system 2802", and "production simulation system 2850" simultaneously or independently run in the so-called client/server environment.

Current computer hardware capable of realizing the general client/server environment can be applied to each of the internal hardware configurations of the server and clients of the simulation cooperating work assignment system, as in the first embodiment, and a detailed description thereof will be omitted in this embodiment.

The operation and use method of the production simulation system 2850 as the characteristic feature of this embodiment and the operation and use method of the work assignment system 2802 of this embodiment (although this partially repeats the description of the first embodiment) will be described next for the descriptive convenience.

<Work Assignment System 2802>

The work standard creation system 2800 creates work standard data containing no manhour data, and the standard manhour setting system 2801 creates a manhour setting file 3601 from the work standard data.

As shown in Fig. 100, the work assignment system 2802 downloads (loads data) the contents of the manhour setting file 3601 and creates a composition table file 6400. The work assignment system 2802 also determines the range of composition in the loaded manhour setting data, composes works within that range in accordance with a predetermined

purpose, corrects the composition (including PF-considered automatic averaging processing to be described later), and outputs the composition. In other words, it may safely be said that the work standard creation system 2800 and standard manhour setting system 2801 exist such that the work assignment system 2802 can

· automatically execute composition,
· allow the user to easily grasp the composition result,
· easily correct the composition contents, and
· do composition matching the set purpose.

Fig. 101 illustrates inputs to the work assignment system 2802, outputs from the work assignment system 2802, and the cooperation between the production simulation system 2850 and the work assignment system 2802.

Referring to Fig. 101, the work assignment system 2802 receives the range (desired range set by the user) to be composed as range data 6502. Work data downloaded in accordance with this range is used for the composing operation. Also, division condition data 6503 for division to stations is input as a condition for composition.

A "station" means a unit (work group) representing a plurality of works of a process in the production line. A station may be physically present in the production line or simply indicate a plurality of work groups that are put together in terms of concept.

As shown in Fig. 102, "composition" here means that

a plurality of works in an order defined by the work standard creation system 2800 are automatically distributed to a plurality of "stations" in accordance with the order of works (including a case wherein the order is changed by the work assignment system 2802).

To automatically create a composition by the work assignment system 2802,

· a composition scheme of sequentially distributing works to a plurality of "stations" without considering the parallel operation of the works (this scheme will be referred to as a "simple division scheme" hereinafter for the descriptive convenience: Fig. 102) or

· a composition scheme that takes parallel operation of works (assembly priority order constraint) into consideration (this scheme will be referred to as a "parallel division scheme" hereinafter for the descriptive convenience: Fig. 103)

can be used.

Fig. 103 shows a user interface for defining the parallel operability of works.

For the descriptive convenience, the example shown in Fig. 103 assumes an assembly order of a total of 14 works with numbers S (start) to 13. The user defines the parallel operation of works, which is recognized in advance on the basis of the constraint on the designed structure of the product to be assembled (the position (upper or lower, or

inner or outer position) of the part to be assembled) and the experience of himself/herself, using work icons and link lines (indicated by solid lines in Fig. 103) for connecting a plurality of work icons, as shown in Fig. 103, while seeing the display of the client computer. In the example shown in Fig. 103, a work icon is symbolized by a circle and a work number in the circle.

In assigning the individual works to stations, the work assignment system 2802 can designate a group of works to be assigned to a single station, as shown in Fig. 104. In this case, considering the constraint not to alter the assembly priority order in accordance with the knowledge of the user's own, he/she selects work icons corresponding to the work group to be designated on the user interface for defining the composition and inputs a single group number (symbol) for the plurality of selected icons, thereby defining a desired group designation for the work assignment system 2802. In the example shown in Fig. 104, work icon (2) and work icon (3) are selected by the user for group designation, and "1" is input as a group number (symbol).

The work assignment system 2802 can also assign a specific operator to each station on the basis of operator information stored in an operator database 6501 shown in Fig. 101.

The quantity of products or semi-fabricated goods (units) to be produced in the target production line will

be described.

In a general production line for manufacturing various units, some units are omitted (fall off) from the production line due to a certain factor generated during the production until a predetermined number of units to be produced by the production line in one day are actually acquired.

Let U be the number of units to be produced by the target production line in one day (to be referred to as the "expected number of products" in the following explanation), and U1 be the number of products which are excluded (omitted) from the production line during the production because of defectives (to be referred to as the "number of defective products" in the following explanation). A quantity U0 of parts (e.g., main body units) as bases to be invested into top of the production line (to be referred to as the "number of initial products invested into top of assembly line" in the following explanation) is given by

$$U0 = U + U1 \qquad \ldots(11)$$

In this embodiment, RU is used as a unit representing a manhour (1 RU = (1/1000) min in this embodiment).

Let H0 be the one-day working time of one crew as a set of a plurality of operators assigned to each station (unit: RU, to be referred to as a "working time" in the following explanation), H be the one-day operation time of one crew (a set of a plurality of operators) (i.e., the operation time of the station) (unit: RU, to be referred to

as an "operation time" in the following explanation), and H1 be the time including the line stop time that should be excluded from the operation time (unit: RU, to be referred to as a "line stop time" in the following explanation). The operation time H is given by

$$H = H0 - H1 \qquad \text{...(12)}$$

Let WF (unit: RU) be the total manhour (total manhour in composition) necessary for all works included in the composition calculated by the work standard creation system 2800, and E be the target composition efficiency (i.e., expected composition efficiency) of the target composition. The number of stations N_{ST} to be divided is given by

$$N_{ST} = (U0 \times WF)/(H \times E) \qquad \text{...(13)}$$

That is, when N_{ST} stations are prepared, the expected composition efficiency E as the above target can be achieved. In this setting, the time (i.e., pitch time T_P) required for work in each station is given by

$$T_P = H/U0 \qquad \text{...(14)}$$

In other words, the relationship represented by equation (14) means that the total manhour of works assigned to one station by the simple division scheme is assigned such that it almost matches the pitch time T_P in average. The station manhours (t1 to tn) of stations 1 to n shown in Fig. 102 satisfy

$$t1, t2, \ldots, tn-1, tn \fallingdotseq T_P \qquad \text{...(15)}$$

The work assignment system 2802 outputs a simple

division window display output 6504 or window display output 6505 considering the parallel operation of works to the display unit of the client computer such that the user can easily confirm the composition result. An output (Excel output 6506) of the composition data (work assignment result) based on a predetermined spreadsheet data format (Excel format in this embodiment, and this also applies to the following description) is also possible.

On the basis of the composition data (work assignment result) in the Excel format, which is acquired from the work assignment system 2802, the production simulation system 2850 creates a model representing the simulation target, sets various conditions (simulation conditions) to be set in the created model in executing simulation using the model in accordance with the actual situation including the operation state (e.g., malfunction or maintenance state) of each station and the number of products (e.g., the expected number U of products) required by an external business office, and presents the simulation result and conditions 6507 at that time to the user.

Unlike the above-described simple division scheme, in the parallel division scheme, for example, works 1, 11, and 3 are linked to the single start work S, as is apparent from the example shown in Fig. 103, so the order defined on the user interface has no priority order. That is, the order of works 1, 3, and 11 which are parallel to each other and have

no priority order relationship therebetween can be changed without any problem. To the contrary, work 4 linked to the start work S is subordinate to work 3 that is also linked to the start work S, and must be executed after work 3, as shown in Fig. 103. Hence, this work 4 cannot be handled on an equality with works 1, 3, and 11 (i.e., handled as a work having no priority order).

In the example shown in Fig. 103, assume that works 1, 3, and 11 are assigned to different stations. Considering the parallel operation of these works, if the manhours of these stations are to be averaged in consideration of values (PF values) representing the performance of these stations, the works can be replaced with each other without any problem. More specifically, in the parallel division scheme, when the works are automatically replaced with each other without altering the constraint on the priority order (in the above example, the constraint that works 1, 3, and 11 has priority over work 4), the manhours of the respective stations can be automatically averaged in consideration of the PF (this will be referred to as "PF-considered automatic averaging" hereinafter).

The preceding/succeeding relationship will be further described by exemplifying work 3 shown in Fig. 103. The network diagram shown in Fig. 103 assumes that the work order transits from the left to the right. Hence, the work S linked immediately before work 3 must always be defined before work

3. In this embodiment, such work S is called a "preceding work" of work 3. On the other hand, works 4 and 5 linked immediately after work 3 must always be defined after work 3. In this embodiment, such works 4 and 5 are called "succeeding works" of work 3.

For example, in accordance with the user's instruction, the work assignment system 2802 loads the simulation result and simulation conditions 6507 used to obtain the simulation result (or receives the division conditions and the PF values of the respective stations) and reassigns the works or corrects the composition (including PF-considered automatic averaging) on the basis of these pieces of information.

As described above, work data downloaded in accordance with the range to be composed (range data 6502) is input to the work assignment system 2802 in composing the works.

Fig. 105 is a view showing a display example of the work data loaded to the memory of the work assignment system 2802.

Referring to Fig. 105, a list of work data is displayed in a field 37706. The "total number NTW of works" is displayed in a field 37707, and the total manhour is displayed in a field 37708. The total manhour WF in composition is displayed in a field 37709.

Items for defining composition conditions are input to a window 37710 (windows 37710a1 to 37710d). Bibliographic data of the calculation result based on the input conditions

is displayed in a window 37720 (windows 37720c1 to 37720e).

More specifically, data related to the above-described equations (11) to (14) are input to the input window 37710. That is, the user inputs the expected number U of products to the field 37710a1 and the number U1 of defective products to the field 37710a2 (at this time, the number U0 of initial products invested into top of assembly line is automatically calculated in accordance with equation (11), and the calculation result is displayed in the field 37710a3).

The user also inputs the working time H0 to the field 37710b1, the line stop time H1 to the field 37710b2 (at this time, the operation time H is automatically calculated in accordance with equation (12), and the calculation result is displayed in the field 37710b3), and the expected composition efficiency E to the field 37710c.

The total manhour in composition WF in equation (13) need not be input by the user, and the total manhour in composition (field 37709) calculated by the system is used, as described above.

In the display window shown in Fig. 105 in the above-described state, when the user clicks on the "calculate" button 37710d, the number N_{ST} of stations is calculated in accordance with equation (13), and the pitch time T_{T} is calculated in accordance with equation (14) on the basis of the respective conditions input to the window 37710.

The number N_{ST} of stations automatically calculated in

accordance with N_{S} = (U × WF)/(H × E) [equation (13)] is displayed in the field 37720a when the value is rounded down or in the field 37720b when the value is rounded up. The calculation that is automatically rounded up or down is displayed as a composition efficiency R1.

In default setting, a value obtained by rounding down the number N_{S} of stations is displayed in the field 37720c1, and the composition efficiency for the number of stations is displayed in the field 37720c1. The value in the field 37720c1 can be changed by correction input (in this case, the composition efficiency in the field 37720c2 is also synchronously updated). The pitch time T_{P} is displayed in the field 37720d.

In this embodiment, the work assignment system 2802 executes composition such that the manhour of each station falls within the range of almost ±10% of the average station manhour (for example, for composition at a composition efficiency of 95%, the manhour of each station falls within the range of 105% to 85% of the pitch time T_{P} as much as possible), expecting that an operator with a large performance value (PF value) is assigned to a station with a large station manhour.

<Providing Composition Plan>

A composition plan provided to the user by the work assignment system 2802 will be described next.

In the above-described display window shown in

Fig. 105, when the user selects the "assign work" button in the field 37720e, automatic work assignment (composition) is executed by the work assignment system 2802, and the simple division window display output 6504 or window display output 6505 considering parallel operation of works is displayed. In the following description, the simple division window display output 6504 and window display output 6505 considering parallel operation of works will be totally referred to as a composition result window (composition correction window).

Fig. 106 is a view showing the display example of the composition result window (composition correction window). Fig. 106 shows the states of works (9001 and the like) assigned to the respective stations (St1 to St5 in the example shown in Fig. 106) and the standard manhours of the stations (9002 and the like) as the calculated work composition result.

When the user selects an "Excel output" 9004 in a file menu 9003 of the composition result window (composition correction window) shown in Fig. 106, an "Excel output window" (Fig. 107) for inputting the name of a file to which the displayed work assignment result is to be transferred is displayed.

In the "Excel output window" shown in Fig. 107, when the user inputs to a field 10001 the name of the file to which the work assignment result is to be transferred, and selects

the "OK" button, an Excel file corresponding to the work assignment result is created, and a "macro execution menu window" (Fig. 108) is displayed.

In a "macro execution menu window" 11001 shown in Fig. 108, when the user selects "create simulated trial cooperation table" 11002, data for transferring the work assignment result to the production simulation system 2850 is created, and a "save as" window (Fig. 109) for the data is displayed.

In the "save as" window shown in Fig. 109, when the user selects a data format (e.g., "text (tab delimiter) (*.txt)") 12001 loadable by the production simulation system 2850, the data is automatically converted into a format for transferring the work assignment result to the simulation module (simulation process) of the production simulation system 2850, and the station manhour is stored in the format (e.g., CSV tab format) loadable by the production simulation system 2850.

Fig. 110 is a view showing the display example of the data stored in the system by the operation in the display window shown in Fig. 109. As shown in Fig. 110, the identification names of the stations are displayed in a field 13001, the station manhours of the stations are displayed in a field 13002, the PF values (default set values) of the stations are displayed in a field 13003, the lower limit PF values (default set values) of the stations are displayed

in a field 13004, and the upper limit PF values (default set values) of the stations are displayed in a field 13005.

The PF value of each station is the average performance value (determined by the degree of difficulty and stability of works in each station and the capability and the degree of skill of the operator assigned to the station) in each station. The lower limit PF value of each station is the minimum valve of the deviation width of the performance of each station according to the time zone. The upper limit PF value of each station is the maximum valve of the deviation width of the performance of each station according to the time zone.

<Production Simulation System 2850>

The production simulation system 2850 creates a production simulation model as shown in Figs. 111 and 112 on the basis of the number of stations transferred from the work assignment system 2802.

More specifically, the production simulation system 2850 can load to itself the data (station manhour shown in Fig. 110) transferred from the work assignment system 2802 as a graphic shown in Fig. 111 or a production simulation model table shown in Fig. 112.

More specifically, like the display example of the production simulation model shown in Fig. 111, for the works assigned to the respective stations and the manhours assigned to the respective stations, the data of the work assignment

result stored in the work assignment system 2802 in accordance with the procedure described above with reference to Figs. 107 to 110 is loaded and set in the production simulation system 2850.

In addition, like the display example of the production simulation model table shown in Fig. 112, the identification names of the stations are set in a field 15001, the station manhours are set in a field 15002, the PF values (default set values) of the stations are set in a field 15003, the lower limit PF values (default set values) of the stations are set in a field 15004, and the upper limit PF values (default set values) of the stations are set in a field 15005.

On the table as shown in Fig. 112, the user can change/input the PF values of the stations, the lower limit PF values of the stations, and the upper limit PF values of the stations. The user can set the PF value, lower limit PF value, and upper limit PF value of each operator to be actually assigned.

In the production simulation model shown in Fig. 111, the user can set items such as an average operator pf, a variation in working speed, and a nonadjusted ratio (yield: the number of defective products; this also applies to the following explanation) in the same manner as that for the actual production line and can set a station where a defective product is to be found and excluded from the production line. In addition, the nonadjusted ratio of each station can be

set from the defective part inclusion ratio of parts (materials) used in each station and the work error ratio. The nonadjusted ratio determined in accordance with the defective part inclusion ratio and work error ratio can be changed by the probability distribution according to the time zone.

In the graphic window of the production simulation model shown in Fig. 111, the user can set not only the stations included in the composition set by the above-described work assignment but also a station (unaided assembly station) that is present independently of the stations in the composition and a readjustment station capable of readjusting a defective product generated in a station in the composition and returning the product to a station in a composition as a nondefective product.

The user must set the manhour of the unaided assembly station and readjustment station in the same way as in the actual production line. For example, in the example shown in Fig. 111, the user sets so that a defective product generated in a 3st (assembly 3) 14001 is to be found in a 4st (process check 1) 14002, 5st (process check 2) 14003, or 6st (process check 3) 14004 and also that the found defective product is readjusted in a readjustment process 14005 and then reinvested into the 4st (process check 1) 14002 as a nondefective product.

Let Y1 be the defective part inclusion ratio, and Y2

be the work error ratio. Assuming that the probability of simultaneous including of the respective defective parts and the probability of simultaneous occurrence of defective part inclusion and work error are very small and negligible, a nonadjusted ratio a1 of a certain station is given by

Nonadjusted ratio = 1 - (defective part inclusion ratio + work error ratio)

$$a1 = 1 - (Y1 + Y2) \quad \ldots(16)$$

However, since it is assumed that the defective product is to be found not in the station where a defective item determined as a defective product has actually occurred but in the station for checking the defective item (i.e., in the example shown in Fig. 111, the 4st (process check 1) 14002 to 6st (process check 3) 14004), setting must be done such that the defective product is excluded (omitted) in the station which should find the defective item.

Letting a be the nonadjusted ratio of the entire composition and U be the expected number of products, the number U1 of defective products is given by

The number of defective products = (the expected number of products/nonadjusted ratio) - the expected number of products

$$U1 = (U/a) - U \quad \ldots(17)$$

The production simulation system 2850 can perform simulation, including a model outside the composition target, such as the readjustment station which is not taken into

consideration by the above-described work assignment system 2802 in its function. For this reason, according to the production simulation system 2850, the degree of influence of the factor outside the composition on the works in the composition set by the work assignment system 2802 and on the production quantity can be confirmed.

Hence, when an environment model outside the composition, which is close to the situation of the actual production line, where the factor outside the composition is defined, is created, and simulation using the environment model is executed by the production simulation system 2850, the user can properly grasp how much the composition plan previously set by the work assignment system 2802 can actually achieve the production quantity.

In the production simulation model shown in Fig. 111, for the work performance,

· a variation in work performance between operators in a single cell, and

· a variation in work performance of a single operator depending on the work time

are taken into consideration.

To take these variations into consideration, in the model (Fig. 111), every time a part is invested into the station, the work performance is calculated by calculating the normal distribution using the PF value, lower limit PF value, and upper limit PF value set in the process time set

table (Fig. 112) and also calculates the process time in the target station using the calculated work performance and station manhour in accordance with

Process time = (station manhour)/(work performance) ...(18)

As described above, the work assignment system 2802 automatically executes composition such that the manhour of each station falls within the range of almost ±10% of the average station manhour (for example, for composition at a composition efficiency of 95%, the manhour of each station falls within the range of 105% to 85% of the pitch time T_{f} as much as possible), expecting that an operator with a large performance value (PF value) is assigned to a station with a large station manhour, and presents the composition plan as a result to the user, as in the display example shown in Fig. 106.

Actually, however, it is often difficult to appropriately assign such an operator. Hence, for the simulation by the production simulation system 2850, the simulation is executed after the user sets the performance of each of the operators to be actually assigned to the simulation target stations. The user confirms the throughput (i.e., the relationship between the production quantity and the operation ratio of each station (operator)) based on the conditions set by himself/herself using the function of the production simulation system 2850.

In this case, to calculate the values such as the nonadjusted ratio (the number of defective products) and line stop time, the user sets data immediately before the actual production or empirical values in the past to the parameters such as the part delivery ratio, defective part inclusion ratio, station error ratio, and serious defect generation ratio before execution of simulation by the production simulation system 2850, and the simulation is executed while appropriately varying the set values in the calculation of normal distribution.

The above detailed parameters settable by the user in accordance with the actual situation are items that are not included in the work assignment system 2802 described above and can be set only in the production simulation system 2850. However, the simulation can also be executed while directly setting the nonadjusted ratio, line stop time, and the like from actual data.

Setting is also possible in the production simulation system 2850 such that defective products generated in some composition lines set in the system as models are readjusted by a common readjustment station, and a nondefective product obtained by readjustment is returned to the composition line where the defective product was previously excluded. Setting in this case will be described with reference to Fig. 113.

Fig. 113 is a view for explaining a model in setting

a common readjustment station for a plurality of compositions.

A block of composed production lines will be called a "cell". In the display example shown in Fig. 113, a model representing the composition (production line) is constituted by a cell 1 (16001), cell 2 (16002), cell 3 (16003), and readjustment cell 4 (16004). The content of each of the cells 1 to 3 is comprised of several stations, as shown in Fig. 111.

In the setting example shown in Fig. 113, a defective product that has been adjusted to a nondefective product (to be referred to as a "readjusted product" hereinafter) by readjustment by the readjustment cell (16004) is returned to the source cell in the cells 1 to 3, where the product was excluded as a defective product, and reinvested to a predetermined station designated in that cell in advance.

For example, as shown in Fig. 114, the readjustment cell (16004) is constituted by several readjustment stations.

Generally, an operator (to be referred to as a readjustment operator hereinafter), who has an ability of restoring such a defective product as a readjusted product, is often charged in another operation outside the composition (e.g., unaided assembly operator, management operator, or alternate operator for an absent standard operator in the composition) as an independent support operator outside the

composition from the viewpoint of production efficiency at the site of production.

In this embodiment, to take such an operator into consideration, the operator estimation of support operators is represented by

Support operator load = alternate operator load + unaided assembly operator load + readjustment operator load + management operator load ...(19)

Alternate operator = the number of operators of one composition × the number of composition × (1 - attendance ratio) ...(20)

The value of the alternate operator calculated by equation (20) is an average value (median value) that varies within the range of the normal distribution depending on the day.

The time (readjustment time) required to restore a defective product as a readjusted product is given by

Readjustment time = number of initial products invested into top of assembly line × (1 - nonadjusted ratio) × time per unit ...(21)

The nonadjusted ratio included in equation (21) varies depending on the day or time zone.

As other factors of the operator estimation of the support operators, values are calculated by

Readjustment operator = readjustment time / operation

time ...(22)

Unaided assembly operator = number of initial products invested into top of assembly line × unaided assembly time per unit ...(23)

Management operator = management operation time / operation time ...(24)

As described above, in this embodiment, support operators estimated by equations (19) to (24) are assigned. Hence, at the actual site of production, if priority is given to the alternate operation in the composition over readjustment, all actual operators corresponding to support operators assigned in advance as a model in the production simulation system 2850 are also expected to be included in the composition as alternate operators due to a long vacation of an operator in the composition. In this case, nobody can readjust defective products generated in the composition (or cell) in the readjustment cell (corresponding to the readjustment cell 16004 shown in Fig. 113).

According to the above-described production simulation system 2850, the following items are possible.

· Independent support operators outside the composition can be set as a simulation model.

· When the support operators are comprised of alternate operators, unaided assembly operators, management operators, and readjustment operators, the user can set the number of support operators.

· The number of alternate operators transferred to the stations in the composition can be changed in accordance with the probability distribution by designating the attendance ratio, probability distribution, average value, and distribution value.

· When the number of operators who are transferred to the stations in the composition as alternate operators is subtracted from the number of support operators, the upper limit value of the number of operators who can actually do the readjustment operation can be set in various ways depending on the day.

Figs. 114A and 114B are views for explaining the structure of the cell of the common readjustment station so as to explain the influence on the number of readjustment stations when an alternate operator is transferred in the composition.

The example shown in Fig. 114A is a display example of a model (17001) when the user sets the number of support operators to three, the number of unaided assembly operators to zero, the number of management operators to zero, and the maximum number of readjustment stations to three. The manhour and performance of each readjustment station are set as shown in a table (17002) of Fig. 114B.

At this time, in the production simulation system 2850, the number of readjustment stations capable of actually operating can be changed to 0, 1, 2, or 3 within the range

of the upper limit value of the number of support operators capable of the readjustment operation depending on the day by subtracting the number of operators transferred to the stations in the composition as alternate operators from the number of support operators.

Thus the user can acquire a simulation result considering the load (manhour) for readjustment of generated defective products, which reveals the number of days when the number of readjustment operators becomes zero, troubles possible in that day (e.g., the number of readjustment stocks), or the influence on the readjustment stocks and production quantity through a predetermined number of days, e.g., one month.

The simulation model and the graphics of the simulation model including the readjustment station shown in Figs. 111, 113, 114A, and 114B basically have the same structure as that of operation of current general drawing software (e.g., Visio available from Microsoft), and a detailed description of the operation itself in this embodiment will be omitted.

<Providing Simulation Condition and Simulation Result to Work Assignment System 2802>

According to the production simulation system 2850 having the above function, when simulation is executed on the basis of the above-described predetermined conditions set by the user, the throughput (production quantity) and the production efficiency and operator efficiency of each

station can be obtained as a simulation result.

If the user cannot be satisfied with the throughput (production quantity) and the like represented by the simulation result based on the set conditions, data as shown in Fig. 115 are output to the work assignment system 2802 to compose the works again. More specifically, the data of station identification names set in a field 18001, the data of station manhours set in a field 18002, the data of the PF values (actual values) of the stations set in a field 18003, the data of the lower limit PF values (actual values) of the station set in a field 18004, and the data of the upper limit PF values (actual values) of the stations set in a field 18005 are output to the work assignment system 2802.

In addition, if the user cannot be satisfied with the throughput (production quantity) and the like represented by the simulation result based on the set conditions, data obtained by converting the nonadjusted ratio to the number of defective products in accordance with equation (17) and the line stop data are output to the work assignment system 2802.

<When the Number of Stations Need Not be Changed>

When the performance data (PF value) of each station is not so smaller than the value that is initially predicted and set by the user in the work assignment system 2802, and the data of the number of defective products and the line stop data are not so larger than the set values, the number

of stations need not be changed even when the simulation values received from the production simulation system 2850 are reflected to the work assignment system 2802.

<PF-Considered Automatic Averaging>

When the user selects "PF-considered automatic averaging" 19006 in a composition menu 19005 of the composition result window (composition correction window) shown in Fig. 116, a "process PF input" window 19007 is displayed.

Figs. 117A and 117B are views showing the full graph display window (corresponding to a display window 19009 in Fig. 116) before and after execution of the PF-considered automatic averaging processing. Figs. 118A and 118B are views showing the "process PF input" window (corresponding to the display window 19007 in Fig. 116) before and after execution of the PF-considered automatic averaging processing.

When the simulation result is loaded from the production simulation system 2850, the work assignment system 2802 displays the "process PF input" window shown in Fig. 118A.

In the "process PF input" window shown in Fig. 118A, the set PF value and loaded values in the simulation of each station before execution of the PF-considered automatic averaging processing are displayed in a "set PF value" column field 20003. A value obtained by multiplying each value in

the column field 20003 by the pitch time is automatically calculated and displayed in a "tp*PF" column field 20004. Each station is displayed in a "process No." column field 20001, and each station manhour is displayed in a "current process manhour" column field 20002.

Stations 1, 2, and 7 (20005) for each of which the station manhour is larger than the value obtained by multiplying the set PF value by the pitch time cannot product the expected number of products.

The user can correct and input a PF value in the "set PF value" column field 20003. For example, when the number of readjusted products reinvested to a certain station is large, and that station has a larger number of products to be worked than the remaining stations, the user may empirically want to set a smaller PF value for actual use than the PF value loaded from the simulation result in consideration of the number of products. In this case, the user corrects and inputs the PF value.

In this embodiment, the value obtained by multiplying the set PF value by the pitch time is set as the target station manhour of each station, and a logic is used to examine work exchange with another station to reduce the manhour of a station having a large (+) difference between the target station manhour and the station manhour (current process manhour), thereby making the station manhour close to the target station manhour.

In the display window shown in Fig. 116, when the user selects an "OK" button 19008 (corresponding to an "OK" button 20006 in Figs. 118A and 118B) the work assignment system 2802 executes the "PF-considered automatic averaging" processing to exchange works in the respective stations such that the manhour of each station becomes close to the target station manhour in consideration of the manhour difference between the current station manhour and the target station manhour of each station and the continuity and parallel operability of the assembly works. If there are group-designated works, the works are exchanged within the constraint that the works designated to a group are assigned to a single station.

The work assignment system 2802 presents the PF-considered automatic averaging state to the user at a predetermined time interval by displaying the bar graph (full graph display window) 19009 (corresponding toe Figs. 117A and 117B) of the manhours of the respective stations.

Execution of the PF-considered automatic averaging processing automatically continues until it is stopped when the user selects a "STOP" button 19010, or no more works to be exchanged make each station manhour to the target station manhour remain. When the user selects the "STOP" button 19010, the PF-considered automatic averaging processing is stopped at that time, and the manhours that reflect the work exchange result to that time are displayed.

Figs. 117B and 118B show the full graph display window

and "process PF input" window, respectively, so as to explain the state after the PF-considered automatic averaging. As is apparent from Figs. 117B and 118B, after the "PF-considered automatic averaging" processing is executed by the work assignment system 2802, the bar graph representing the manhour of each station is compared with that before execution and averaged, so the station manhour (current process manhour) of each of stations 1, 2, and 7 is obviously smaller than the value obtained by multiplying the set PF value by the pitch time.

Fig. 119 is an explanatory view showing work movement (exchange) without altering the priority order and that with alteration of the priority order. As conditions shown in Fig. 119,

· work No. 2 of station 1 and work No. 6 of station 3 can be exchanged in accordance with the priority order (the priority order is not altered), and

· work No. 2 and work No. 7 of station 1 cannot be exchanged in accordance with the priority order (because work No. 6 preceding to work No. 7 is in movement source station 3, and the priority order is altered).

It can be known that some works can be moved/exchanged, and the remaining works cannot because of the priority order.

Fig. 120 is a flow chart showing the control procedure of the "PF-considered automatic averaging" processing.

Referring to Fig. 112, in step S2301, data are loaded,

and initial conditions are set. As detailed data items to be loaded in this step, the number of works to be composed, the manhour of each work, the preceding/succeeding relationship, group designation data, which station each work is assigned, the manhours of groups and preceding/succeeding relationship, data representing which station group-designated works are assigned, the number of stations, the manhour of each station, the number of parallel stations, data of the value obtained by multiplying the set PF value by the pitch time.

In step S2302, processing of sequentially moving (exchanging) works from stations ST to N having large manhour differences (+) to stations St having small manhour difference (-) is repeatedly examined every time a work is moved (exchanged).

In step S2303, the manhour difference between the target station manhour and the current station manhour of each station is calculated, and the stations are rearranged in the descending order of calculated manhour differences.

Fig. 121 is an explanatory view of step S2303 of calculating the manhour difference between the target station manhour and the current station manhour of each station. For example, for parallel station st5 whose number of parallel stations is 2 (st5-1 and st5-2), the manhour difference is set by dividing, by the number of parallel stations, the value obtained by subtracting the current

station manhour from the target station manhour. In this case, the stations are sequentially arranged in the descending order from the station with the large "+" difference to the station with the small (-) difference, i.e., in the order of st8, st5, st1, st2, st7, st3, st6, and st4 (st1, st2, and st7 are the same because the difference is ±0).

Next, in step S2304, the difference between a target station (St to N) with the large manhour difference (+) and the set PF value manhour difference of an exchange station St is calculated.

Ins step S2305, work movement/exchange between the exchange station St and the target station (St to N) with the large manhour difference (+) is repeatedly examined.

In step S2306, the process branches because the logic changes between a case wherein the target station St with the large manhour difference is after the exchange station St and a case wherein the target station is before the exchange St.

Fig. 122 is an explanatory view of the case wherein the averaging target station St (Stmaxj) is present after the exchange station St (Stju). When the station manhour difference of station 3 after station 1 is larger than that of station 1, for example, an examination is done to move a work A of station 3 to station 1 and instead a work B of station 1 to station 3. The logic for this case comprises

steps S2307 to S2311.

In step S2307, works between the exchange station Stju+1 and the target station Stmaxj are confirmed. In the case shown in Fig. 122, works between station 2 immediately succeeding exchange station 1 and target station 3 are listed.

In step S2308, for a movement candidate work from the target station Stmaxj to the exchange station Stju, it is confirmed that no preceding work of the movement candidate work is present between the stations. In the case shown in Fig. 122, for the work A as a movement candidate from target station 3 to exchange station 1, it is confirmed that no preceding work of the work A is included in the listed works. If it is confirmed that the preceding work of the work A is included in the listed works, the work A cannot be moved; otherwise, the work A can be moved.

In step S2309, works between the exchange station Stju and the target station Stmaxj-1 are confirmed. In the case shown in Fig. 122, works between exchange station 1 and station 2 immediately preceding target station 3 are listed.

In step S2310, for a movement candidate work from the exchange station Stju to the target station Stmaxj, it is confirmed that no succeeding work of the movement work is present between the stations. In the case shown in Fig. 122, for the work B as a movement candidate from exchange station 1 to target station 3, it is confirmed that no succeeding

work of the work B is included in the listed works. If it is confirmed that the succeeding work of the work B is included in the listed works, the work B cannot be moved; otherwise, the work B can be moved.

In step S2311, movement/exchange of the target station St having the large manhour difference is executed. However, this processing is done after confirming that the works to be exchanged have no preceding/succeeding relationship therebetween.

Fig. 123 is an explanatory view of the case wherein the (target) station St (Stmaxj) having the large manhour difference is present before the exchange station St (Stju). Assume that when the station manhour difference of station 1 before station 3 is larger than that of station 3, for example, an examination is done to move the work A of station 1 to station 3 and instead the work B of station 3 to station 1. The logic for this case comprises steps S2312 to S2316.

In step S2312, works between the target station Stmaxj and the exchange station Stju-1 are confirmed. In the case shown in Fig. 123, works between target station 1 and station 2 immediately preceding exchange station 3 are listed.

In step S2313, for the movement candidate works from the target station Stmaxj to the exchange station Stju, it is confirmed that no succeeding work of the movement candidate work is present between the stations. In the case shown in Fig. 123, for the work A as a movement candidate

from target station 1 to exchange station 3, it is confirmed that no succeeding work of the work A is included in the listed works, as in the above-described step S2308.

In step S2314, works between the target station Stmaxj+1 and the exchange station Stju are confirmed. In the case shown in Fig. 123, works between station 2 immediately succeeding target station 1 and target station 3 are listed.

In step S2315, for a movement candidate work from the exchange station Stju to the target station Stmaxj, it is confirmed that no preceding work of the movement work is present between the stations. In the case shown in Fig. 123, for the work B as a movement candidate from exchange station 3 to target station 1, it is confirmed that no preceding work of the work B is included in the listed works, as in the above-described step S2310.

In step S2316, movement/exchange of the target station St having the large manhour difference is executed. However, this processing is done after confirming that the works to be exchanged have no preceding/succeeding relationship therebetween.

In step S2317, the repetitive processing of moving/exchanging a work is ended at the time of movement/exchange or upon confirming that no works to be moved remain.

In step S2318, the repetitive processing for examination every time a work is moved (exchanged) is ended

upon confirming that no works to be moved remain.

<When the Number of Stations Must Be Changed for Reassignment of Works)

When the performance data (PF value) of each station is much smaller than the value that is initially predicted and set in the work assignment system 2802, ~~or~~ the data of the number of defective products and the line stop data are larger than the set values, the number of stations must be changed when the simulation values received from the production simulation system 2850 are reflected.

<Reassignment of Works>

Various data transferred from the production simulation system 2850 to the work assignment system 2802 are displayed in a display window shown in Fig. 124. More specifically, in the display window shown in Fig. 124, the data of the number of defective products is input to a field 32710a2 as the number of defective products (U2) (60 in Fig. 124). The line stop data is loaded to a field 32710b2 as the line stop time (H1) (10 min, i.e., 10,000 RU in Fig. 124).

The format itself of the display window shown in Fig. 124 is the same as that of the above-described display window shown in Fig. 105, and a detailed description thereof will be omitted.

Before reassignment of work composition, the user inputs the target composition efficiency (i.e., expected

composition efficiency E) (85% in Fig. 124) to a field 32710c in consideration of the performance data (PF value) of each station and then presses a "calculate" button 32710d. On the basis of automatic calculation based on the conditions input to a window 32710, the number N_{ST} of stations (10 in Fig, 124) is displayed in a field 32720c1 in accordance with the above-described equation (13), and the pitch time T_P (1396.66 in Fig. 124) is displayed in a field 32720d in accordance with equation (14).

When the "work assignment" button in a field 32720e is selected by the user, work assignment (composition) is executed, and the simple division window display output 6504 or the window display output 6505 considering the parallel operation of works is displayed. The simple division window display output 6504 and window display output 6505 considering the parallel operation of works will be totally referred to as a composition result window (composition correction window). Fig. 125 is a view showing a composition result window (composition correction window).

<Providing Composition Plan>

When the user selects the "Excel output" in the file menu of the composition result window (composition correction window) shown in Fig. 125, an "Excel output window" (Fig. 126) for inputting the name of a file to which the work assignment result is to be transferred is displayed.

When the user inputs the name of a file to which the

work assignment result is to be transferred to a field 29001 of the "Excel output window" shown in Fig. 126 and selects the "OK" button, an Excel file is created, and a "macro execution menu window" shown in Fig. 127 is displayed.

In a "macro execution menu window" 30001 shown in Fig. 127, when the user selects a "create simulated trial cooperation table" 30002, data for transferring the work assignment result to the simulation is displayed, and a "save as" window shown in Fig. 128 is displayed.

In the "save as" window shown in Fig. 128, when the user selects a data format (e.g., "text (tab delimiter) (*.txt)") 31001 loadable by the production simulation system 2850, the data is automatically converted into a format for transferring the work assignment result to the simulation, and the station manhour is stored in the format (e.g., CSV tab format) loadable by the production simulation system 2850.

Fig. 129 is a view showing the display example of the data stored in the format loadable the production simulation system 2850. As shown in Fig. 129, the identification names of the stations are displayed in a field 32001, the station manhours are displayed in a field 32002, the PF values (work assignment system set values) of the stations are displayed in a field 32003, the lower limit PF values (work assignment system set values) of the stations are displayed in a field 32004, and the upper limit PF values (work assignment system

set values) of the stations are displayed in a field 32005.

<Work Assignment Cooperating Production Simulation>

The production simulation system 2850 loads data (Fig. 129) stored in accordance with the user operation in the display window shown in Fig. 128 as a production simulation model, as shown in Fig. 130.

Fig. 130 is a view for explaining data to be loaded and corrected by the production simulation system 2850.

Referring to Fig. 130, the identification names of the stations are displayed in a field 33001, the station manhours are displayed in a field 33002, the PF values (work assignment system set values) of the stations are displayed in a field 33003, the lower limit PF values (work assignment system set values) of the stations are displayed in a field 33004, and the upper limit PF values (work assignment system set values) of the stations are displayed in a field 33005.

On the table as shown in Fig. 130, the user can change/input the PF values of the stations, the lower limit PF values of the stations, and the upper limit PF values of the stations and actually sets the PF value, lower limit PF value, and upper limit PF value of each operator to be actually assigned. The subsequent operation is the same as that of the above-described production simulation system 2850. As a result of simulation, the user repeats the above-described series of operations until re-execution of assignment for work composition becomes unnecessary.

<Application Example of Work Assignment Cooperating Production Simulation>

An application example in which mass production of products is started in the target production line using the above-described production simulation system 2850 will be described next.

As described above, a change in the number of stations and reassignment of various works in accordance with the change are mainly required in the following three cases. That is:

1. in a case wherein the PF of each operator at the actual site of production is much smaller than the user's initial expectation, to produce a predetermined number of products (nondefective products) that should be produced regardless of the PF at the site of production (i.e., the actual production situation), the composition efficiency must be reduced to a value that can manage production of the predetermined number of products, and the number of stations must be increased to a value that can manage production of the predetermined number of products in accordance with the reduced composition efficiency.

2. In a case wherein the nonadjusted ratio a1 of products at the actual site of production is much lower than the user's initial expectation, to produce a predetermined number of products (nondefective products) that should be produced by the production line regardless of the nonadjusted

ratio, the number of stations must be increased in accordance with the necessity that the number of products invested into top of the assembly line must be increased and the pitch time is shortened to compensate for the number of defective products.

3. In a case wherein the defective part inclusion ratio and part delivery ratio are much poorer than the user's initial expectation, to produce a predetermined number of products (nondefective products) that should be produced by the production line even under these circumstances, the number of stations must be increased in accordance with the necessity that the pitch time is shortened to compensate for the line stop time in the production line.

Generally, the above situations readily conspicuously occur almost during the three-month period from the start of mass production in the production line of the target product. During this period, the user sets the actual defective part ratio, defective part inclusion ratio, expected station error ratio, the PF value of each operator, and the like in consideration of the probability distribution and executes simulation based on the set conditions using the production simulation system 2850, as described above, in accordance with the situation that changes due to various factors at a timing immediately before the start of production. Thus the user can determine the preconditions for work assignment, including the number of defective

products, line stop time, expected composition efficiency, and the PF value of each station, in accordance with the actual situation of the production line. That is, operation aid according to only the function of the work assignment system 2802 is work assignment under static conditions (predicted and fixed at a certain timing). However, as described above in this embodiment, when the function of the work assignment system 2802 and that of the production simulation system 2850 are used in cooperation, work assignment based on dynamic conditions (adapted to a situation that changes) is realized.

Fig. 131 is a view showing the expectation table of the nonadjusted ratio, stop time, and composition efficiency for three months after the start of mass production.

Referring to Fig. 131, M (min) be (break time + preparation time), U be the expected number of products (34001), a be the expected nonadjusted ratio (34002), U0 be the number of initial products invested into top of assembly line (34003), H1 be the expected line stop time excluding (break time + preparation time) MRU, E be the expected composition efficiency (34004), and F0 be the expected production quantity ratio (34005).

In this case, the number U1 of defective products is given by

$$U1 = (U / a) - U$$

in accordance with equation (17).

The number (U0) of initial products invested into top

of assembly line is given by

$$U0 = U + U1$$

in accordance with equation (11).

Letting H0 be the working time, the operation time H is given by

$$H = H0 - (H1 + M)$$

in accordance with equation (12).

A loss ratio f by the expected line stop time H1 is given by

$$f = H1 / H \quad \ldots(25)$$

The expected production quantity ratio F0 is given by

$$F0 = a \times (E / 0.95) - f \quad \ldots(26)$$

The expected production quantity ratio F0 represented by equation (26) is 100% when the number of defective products is assumed to be zero, the line stop time excluding the (break time + preparation time) MRU is assumed to be 0 RU, and the composition efficiency is assumed to be 95% composition targets during the stable production period after the above-described almost three months after the start of mass production.

A production quantity S is predicted by multiplying the number of products during the stable production period by the expected production quantity ratio F0. At this time, assume that an operator during the stable production period is set as an operator assigned to the composition. A production plan is made aiming at eliminating various kinds

of losses during the three months when the production is unstable and achieving the composition targets and the target production quantity during the stable production period from the fourth month.

Letting S0 be the number of products during the stable production period, the expected production quantity S at a certain timing is given by

$$S = S0 \times F0 \qquad \ldots(27)$$

This value is set as the expected number U of products, as in a column 34001 shown in Fig. 131.

Referring to Fig. 131, the production quantity during the stable production period (from the fourth month) is set to 240 units/day. The expected production quantity ratio F0 is calculated by substituting the expected nonadjusted ratio a, expected line stop time H1 excluding M min, and expected composition efficiency E at the early stage of or immediately before each of the first, second, and third months before the stable production period into the above equations, and the calculated value is multiplied by the production quantity, i.e., 240 units/day during the stable production period, thereby calculating the expected number U of products.

The value of the expected number U of products calculated in the above way in the production department is calculated assuming that the actual production can be realized. The expected number U of products planned once must be absolutely achieved because various related plans

(e.g., the sales plan in the sales department and the member order plan in the procurement department) will be made. However, generally, during the above-described about three months immediately after the start of mass production, the expected nonadjusted ratio, expected stop time, and expected composition efficiency are different from expectations in fact. It is therefore difficult to ensure the expected number U of products unless the initial plan is dynamically changed in accordance with the situation. In addition, the PF of each operator is not uniform, and the degree of skill also normally varies depending on the operator and work.

Fig. 132 is a view showing an example of inputs to the work assignment system 2802 on the basis of numerical values of the first month (immediately before or at the early stage of the first month) of the table shown in Fig. 131 when the expected nonadjusted ratio is 70%, the expected stop time is 60 min, and the expected composition efficiency is 50%.

Fig. 133 is a view showing an example of inputs to the work assignment system 2802 on the basis of numerical values of the second month (immediately before or at the early stage of the second month) of the table shown in Fig. 131 when the expected nonadjusted ratio is 80%, the expected stop time is 50 min, and the expected composition efficiency is 70%.

Fig. 134 is a view showing an example of inputs to the work assignment system 2802 on the basis of numerical values of the third month (immediately before or at the early stage

of the third month) of the table shown in Fig. 131 when the expected nonadjusted ratio is 90%, the expected stop time is 45 min, and the expected composition efficiency is 80%.

Fig. 135 is a view showing an example of inputs to the work assignment system 2802 on the basis of numerical values of the fourth month (immediately before or at the early stage of the fourth month) of the table shown in Fig. 131 when the expected nonadjusted ratio is 100%, the expected stop time is 0 min, and the expected composition efficiency is 95%.

Fig. 136 is a view showing a work assignment result calculated by the work assignment system 2802 on the basis of the numerical values of the fourth month shown in Fig. 135 of the input examples shown in Figs. 132 to 135. The work assignment results similarly calculated for the first, second, and third months are different only in the position of the line of pitch time and are not illustrated.

Fig. 137 is a graph showing a prediction of the relationship between the cumulative number of products and the production time per unit for every 1/2 month of the three months based on a static prediction line.

Generally, the skill of an operator for a work is said to be proportional to the logarithm of the cumulative number of products (the time required to produce one unit is inversely proportional to the logarithm of the cumulative number of products) (skill theory). The skill here means not only that the operation speed of the operator increases but

also various improvements and a decrease in error ratio are included.

The prediction error width becomes large as the cumulative number of products increases, as indicated by the broken lines in Fig. 137. The deviation width of the time required to produce one unit decreases in accordance the logarithm of the cumulative number of products. Hence, work assignment by the user is preferably executed first on the basis of the static prediction line while predicting the situation of every month after the above-described start of mass production until the elapse of three months. The prediction line is prepared on the basis of the theory of "skill ratio".

Figs. 138, 139, and 140 are graphs showing predictions of the relationships between the cumulative number of products and the number of defective products, the line stop time, and the work time of each station for every 1/2 month of the three months after the start of mass production based on static prediction lines, respectively, as in Fig. 132.

As days elapse for the production line (the cumulative number of products increases), the user can obtain pieces of information close to the actual situation, which are necessary for calculation of the predicted values. Hence, the predicted values shown in Figs. 138 to 140 must be dynamically corrected in accordance with the actual situation about every 1/2 month. In this case, the user can

do effective prediction according to the actual situation using the production simulation system 2850, as described above, unlike a case wherein only the work assignment system 2802 is used because the production simulation system 2850 has detailed parameters that can be adapted to actual data.

The user preferably dynamically corrects the values in accordance with the actual situation about every 1/2 month using the production simulation system 2850. More specifically, the user preferably supplies data representing conditions set in the work assignment system 2802 and the results calculated by the work assignment system 2802 in accordance with the conditions to the work assignment system 2802, thereby correcting the input conditions as shown in Figs. 132 to 135 and correcting the composition plan immediately before the start of production of each of the first to fourth months.

As described above, as in the above-described second embodiment, the user is expected to properly achieve the expected number of products by building a system that cooperates the work assignment system 2802 with the production simulation system 2850 and correcting the composition plan in accordance with the situation, e.g., every predetermined time immediately before and after the start of production of mass-produced products.

That is, according to the above-described simulation cooperating work assignment system, the output data of the

work assignment system 2802, i.e., the number of stations, station manhours, assignment operation of the stations, and use parts of the stations are loaded to the production simulation system 2850 so that a simulation model (Figs. 111 and 112) in the production simulation system 2850 can be determined.

In the production simulation system 2850, the readjustment process or the like, which is not covered by the function of the work assignment system 2802, can be reflected to the simulation model (Figs. 113, 114A, and 114B) by an easy operation, and simulation is executed using the simulation model. Hence, conditions for assignment of various works by the work assignment system 2802 can be determined in a state closer to the actual situation.

According to the work assignment system 2802, work assignment can be calculated in consideration of the difference in the number of assembled units between the stations due to the actual defective part (material) inclusion ratio or actual error ratio of each station, or the difference and variation in the PF between the stations, and the loads of stations can be averaged. Thus, the actual loads of the stations balance, and a composition plan capable of achieving the expected number of products can be made.

When the user executes prediction on the basis of the production situation immediately before the practice in the production line and sets the number of defective products,

line stop time, and composition efficiency in the work assignment system 2802 in accordance with the prediction, and the work assignment system 2802 calculates the work assignment on the basis of the set conditions, a serious trouble that the number of stations is too small to achieve the expected number of products in actual production can be prevented.

Being aided by the above-described simulation cooperating work assignment system, the user can easily make a composition plan capable of achieving the expected number of products before actual production of the products and also easily execute adjustment for moving a work from a neck station which is found for the first time during actual production to another station or exchange a work requiring a large manhour and included in the neck station with another station which has a margin for the manhour, so large loss of work time can be prevented. In addition, when the number of stations is too small, large loss of hardware and work time in increasing the number of stations can be minimized.

That is, according to the simulation cooperating work assignment system described in the second embodiment, unlike the prior art in which an experienced chief of the workshop, who knows various works well, manually arranges an enormous number of works to average the load balance of the stations in consideration of the PF (performance value) of each station, which is determined by the capability of each

operator and the difficulty of a work, even an inexperienced user can easily make an optimum composition plan while taking the PF into consideration, so the work manhour can be largely reduced.

[Other Embodiment]

The object of the present invention can also be achieved by supplying a storage medium (or recording medium) in which software program codes for realizing the functions of the above-described embodiment are recorded to an apparatus which operates as the above-described subsystem or the server/client, and causing the computer (or a CPU or an MPU) of the system or apparatus to read out and execute the program codes stored in the storage medium. In this case, the program codes read out from the storage medium realize the functions of the above-described embodiment by themselves, and the storage medium storing the program codes constitutes the present invention. The functions of the above-described embodiment are realized not only when the readout program codes are executed by the computer but also when the OS (Operating System) running on the computer performs part or all of actual processing on the basis of the instructions of the program codes.

The functions of the above-described embodiment are also realized when the program codes read out from the storage medium are written in the memory of a function expansion board inserted into the computer or a function expansion unit connected to

the computer, and the CPU of the function expansion board or function expansion unit performs part or all of actual processing on the basis of the instructions of the program codes.

As has been described above, according to the work assignment system of the first and second embodiments, composition can be efficiently executed.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.